Application of SWAT for sediment yield estimation in a mountainous agricultural basin

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Introduction

SWAT (Soil and Water Assessment Tool) is a physically based hydrological model that predicts the impact of land management practices on water, sediment and agricultural nutrient yields in large watersheds over long periods of time. It has been used successfully to simulate runoff, sediment yield and nutrient for many watersheds across the U.S., Europe and Asia.

The Chaohe basin with an area of 5340 km^2 is the main water contribution area to Miyun reservoir, the largest reservoir in North China. Topography varies within Chaohe basin. The rugged landscape dominates the upstream while hills dominate downstream. According to the analysis of records from three hydrologic stations at this basin, different landscape areas are characterized by different patterns of runoff and sediment loads.

In this study, we selected the upstream area to evaluate the applicability of SWAT for predicting sediment yields. The sensitivity analysis of model factors was first performed, the most sensitive parameters were then calibrated, and the calibrated model was finally used to assess sediment loads for identifying critical erosion areas.

Methods

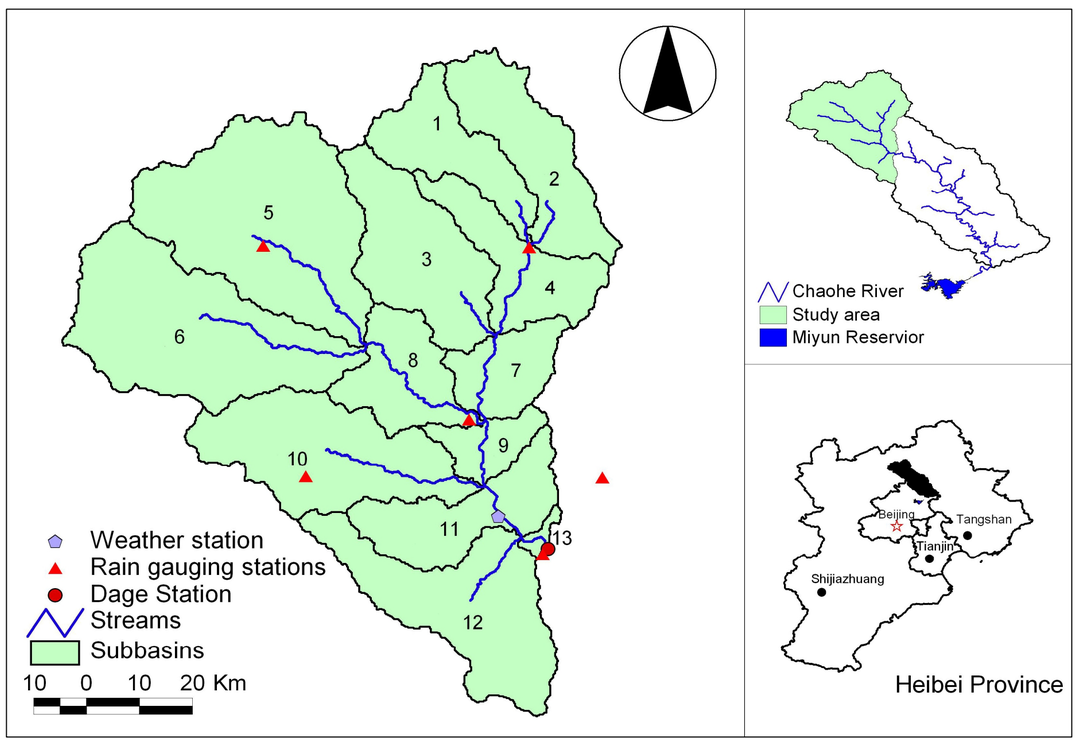


Figure 1. Location of study area

Model evaluation criteria

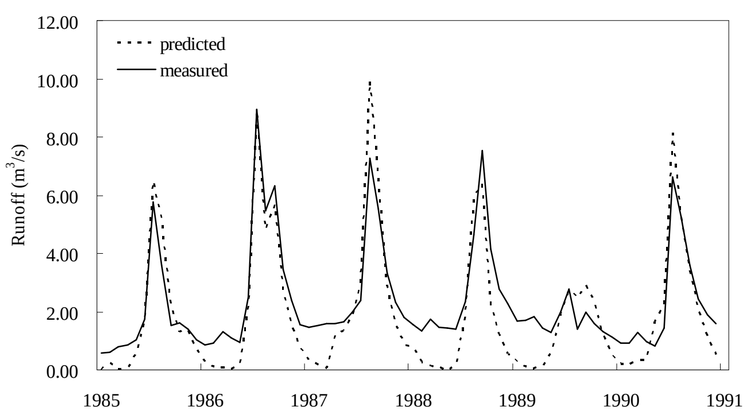
$$E_{NS} = 1 - \frac{\sum_{i=1}^{n}(O_i - P_i)^2}{\sum_{i=1}^{n}(O_i - \overline{O})^2}$$

$$R^2 = \frac{\left(\sum_{i=1}^{n}(O_i - \overline{O})(P_i - \overline{P})\right)^2}{\sum_{i=1}^{n}(O_i - \overline{O})^2 \sum_{i=1}^{n}(P_i - \overline{P})^2}$$

Where, n is the number of measured data, O_i and P_i are the measured and predicted data at time i, and are the mean of measured and predicted data.

Results

Figure 2. Time-series plot of monthly runoff at Dage station during the calibration (1985-1987) and validation period (1988-1990)



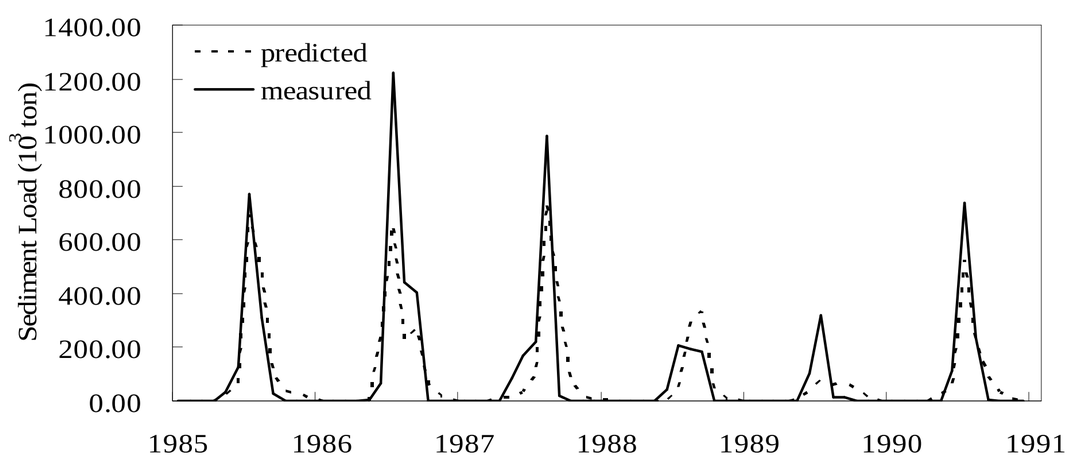


Figure 3. Time-series plot of monthly sediment loads at Dage station during the calibration (1985-1987) and validation period (1988-1990)

Component	Simulation period	E_{NS}	R^2
Runoff	Calibration	0.81	0.93
	Validation	0.51	0.78
Sediment load	Calibration	0.76	0.80
	Validation	0.72	0.79

Table 1. Statistics for runoff and sediment load

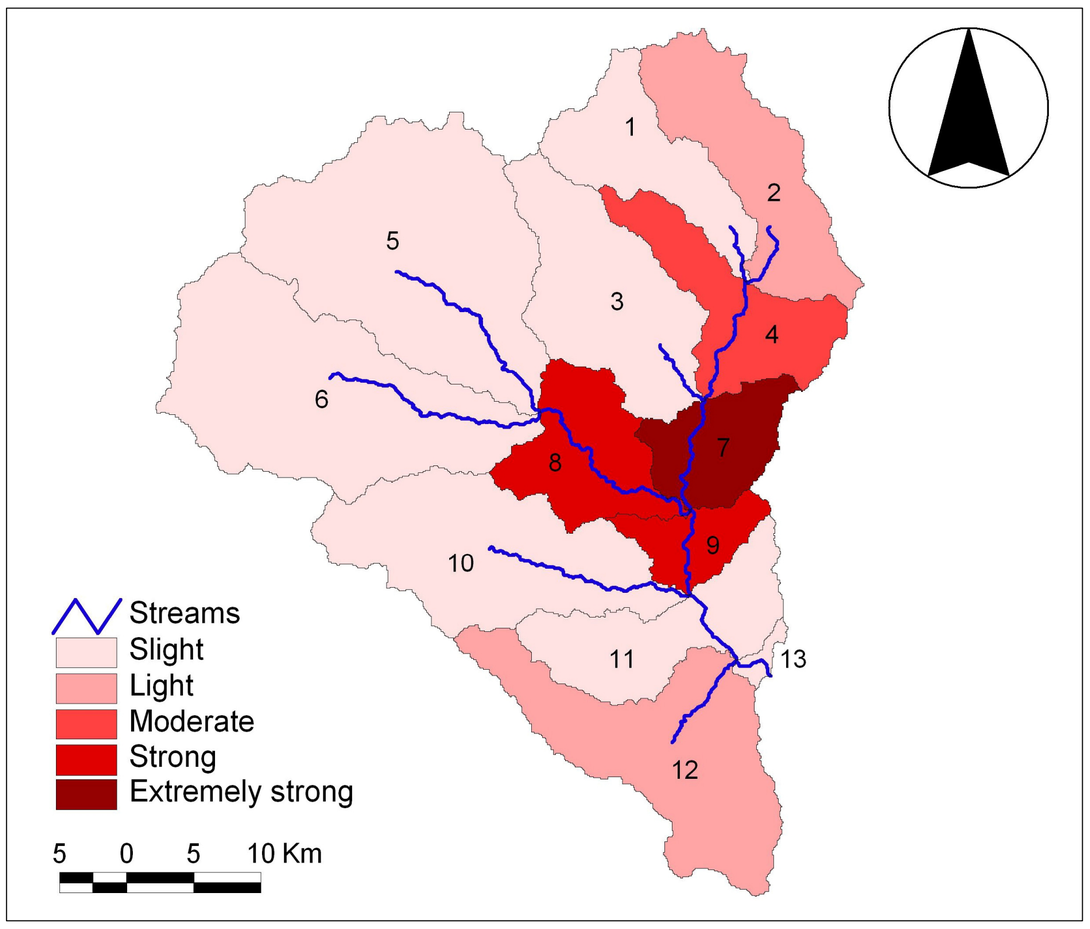


Figure 4. Soil erosion risk map

Conclusion

In this study, the SWAT model was applied to a 1850 km2 basin around Dage station in the upper stream of Chaohe river. The monthly measured runoff and sediment load at Dage station from 1985 to 1987 were used to calibrate the model and the data during 1988 - 1990 were used for model validation. The results of runoff and sediment simulations were all satisfactory with E_{NS} and R^2 above the criteria values, respectively. Based on the simulation results, furthermore, the soil loss classes map was generated and the sub-basins where are dominated by agricultural upland areas were identified to be critical erosion areas. The study revealed that SWAT could be applied for sediment load estimation and identification of critical areas in mountainous agricultural watershed after a great calibration effort.

Supported by the 2007 project of KWEF, Japan