

Simulation analysis of jiujiang river basin runoff based on swat model

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Abstract. This paper discussed the feasibility of application the Soil and Water Assessment Tools (SWAT) model in the Yangtze River Basin of Jiujiang. Two statistical indicators were used for model evaluation; i) coefficient of determination (R²) and ii) Nash-Sutcliffe efficiency index (Ens). The software of SWAT-CUP was used to calibrate and validate the model based on the measured data from 2000 to 2015 in JiuJiang hydrological station, which could assist in determining the applicability of the model to the basin. Results indicated R² being 0.82 and 0.76; Ens being 0.78 and 0.72 in terms of the calibration and verification periods, both of which meeting the requirements, It suggested that the SWAT model could be able to well simulate the Yangtze River Basin of Jiujiang watershed.

1. Introduction

The hydrological model is widely used in hydrological field. Calibration and validation are recognized as vital processes of modeling accomplishments before they are applied into a special case. Previously, several methods have been proposed for calibration and validation during the decision-making process [1, 2].

The main purpose of this study is to calibrate and validate the SWAT hydrological model for Jiujiang river basin, and measure its performance by using two statistical metrics, namely, coefficient of determination (R²) and the Nash-Sutcliffe efficiency index (Ens).

2. Methodology

Distributed hydrological model has a strong physical mechanism, which can effectively use the space data information to simulate the river basin in the complicated hydrological physical process [3]. The SWAT hydrological model is a kind of distributed hydrological model, which is based on ArcGIS. It has been proved as a reliable model in simulating hydrological characteristics at basins scale and is widely used in Stream flow simulation, simulation of pollutants migration, watershed underlying surface conditions change and climate change response simulation, etc [4, 5].

The establishment and operation the SWAT model in Jiujiang basin were based on the processes including loading of digital elevation model (DEM), sub basin delineation, loading of soil and land use data, meteorological data input, hydrological response unit (HRU) identification, input file generation and editing, the SWAT model running, sensitivity analysis, parameter calibration, as well as model validation. Runoff dataset in JiuJiang hydrological station of 16 years were used for running the SWAT



model in this study. Data of the year 2000 were applied for warming up the SWAT model. After it, date from 2001 to 2010 were chosen for modelling calibration and data from 2011 to 2015 for modelling validation.

Moreover, R2 and Ens are selected as statistical indicators to evaluate the applicability of the proposed model. The expressions of R2 and Ens can be presented as follows:

$$R^2 = \left\{ \frac{\sum_{i=1}^n (Q_{0i} - Q_{avg}) (Q_{pi} - Q_{pavg})}{\sqrt{\sum_{i=1}^n (Q_{0i} - Q_{avg})^2} * \sqrt{\sum_{i=1}^n (Q_{pi} - Q_{pavg})^2}} \right\} \quad (1)$$

$$Ens = \left\{ 1 - \frac{\sum_{i=1}^n (Q_{0i} - Q_{pi})^2}{\sum_{i=1}^n (Q_{0i} - Q_{avg})^2} \right\} \quad (2)$$

where O_{0i} is the observed runoff discharge at time i ; Q_{avg} is the average observed runoff discharge; Q_{pavg} is the average simulated runoff discharge; Q_{pi} is the simulated runoff discharge at time i and n is the number of registered runoff discharge data. Generally, the value of Ens nearly 1 corresponds to the higher the credibility of the model. The average annual error between the simulated and measured values should be less than 15% of the measured value, which is the monthly average $R^2 > 0.6$ and $Ens > 0.5$ [6].

3. Results and discussion

This study combines the use of automatic rate of the SWAT-CUP software with manual parameter determination to achieve a rapid and efficient rate verification work. Fig.1 illustrates the sensitivity analysis of parameters based on the SWAT-CUP. In this simulation, the most sensitive parameter is V_CH_N2 that is defined as the runoff curve coefficient, and the least sensitive parameter is R_SOL_AWC that represents the soil available water content. Results show that runoff simulation outputs are the first-rate compared with the observed runoff discharge (Figs.2 and 3). In this study, the validation results are acceptable compared to the calibration results. It suggests an outstanding performance when the values of R2 are 0.82 and 0.76; the values of Ens are 0.78 and 0.72 in terms of the calibration and verification periods.

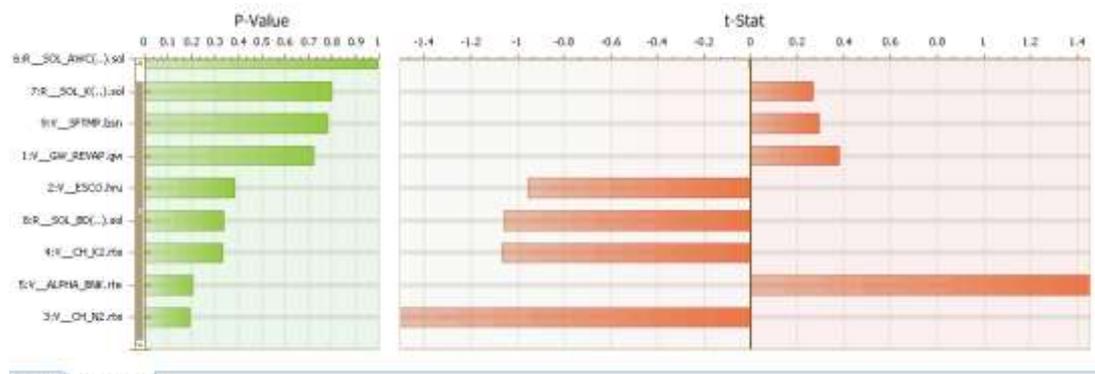


Figure 1. Sensitivity analysis of parameters based on the SWAT-CUP.

During the calibration period (Fig.3), it is obvious that the results of wet seasons are better than those of dry seasons. The major reason arises from the effect of lake in basin. But the simulation results in the validation period are significantly preferred, In the case of the same trend, the main error may be caused by the accuracy of the input data.

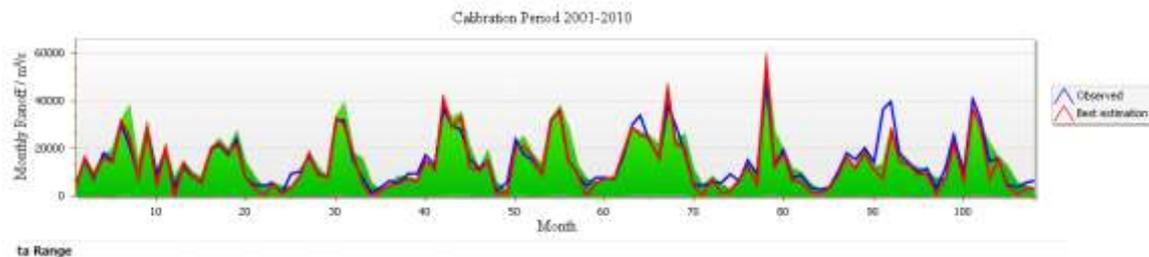


Figure 2. Solutions of Calibration Period from to2001-2010.

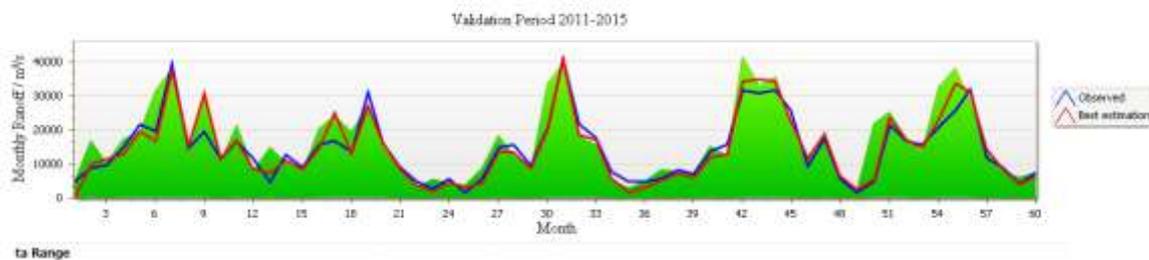


Figure 3. Solutions of Validation Period 2011-2015.

4. Conclusion

In this study, the SWAT model is applied to a sub basin of the Yangtze River Basin, The model was calibrated and validated by using the measured runoff data obtained from the JiuJiang hydrological station from 2000 to 2015. Results indicate that the value of Ens and the value of R2 are higher than the criteria values, which suggests that the SWAT model is applicable to the Jiujiang basin of the Yangtze River Basin.

A further direction for this study is to improve the accuracy of modeling inputs. A series of soil parameters such as soil moisture, soil saturated water conductivity should be achieved through field experiments instead of calculated by running the SPAW software. The improvement of original data will make the results more reliable.

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