International Journal of Current Advanced Research
ISSN: O: 2319-6475, ISSN: P: 2319-6505, Impact Factor: 6.614
Available Online at www.journalijcar.org
Volume 8; Issue 09 (A); September 2019; Page No.19809-19812
DOI: http://dx.doi.org/10.24327/ijcar.2019.3848.19812

Research Article

RUNOFF SIMULATION ANALYSIS OF SWAT MODEL IN PLAIN WATERSHED: A CASE STUDY OF BALIHE LAKE BASIN, CHINA

Jiazhu Lan, Meifang Zhong, Yixin Xu* and Hai Huang

Research Center for Engineering Ecology and Nonlinear Science, North China Electric Power University, Beijing, 102206, China

ARTICLE INFO

Article History:
Received 06th June, 2019
Received in revised form 14th July, 2019
Accepted 23rd August, 2019
Published online 28th September, 2019

Key words:

Balihe Lake basin, SWAT model, runoff coefficient, runoff, rainfall

ABSTRACT

In order to explore the applicability of SWAT model in plain watershed, a case study about the runoff simulation in an actual plain water shed was performed. Based on the SWAT model of Balihe Lake Basin established in this study, the monthly average water flow of the basin from 2010 to 2016 was simulated utilizing the hydro meteorological data, DEM data and land use data in the relevant period. Owing to the high average annual evaporation in this basin, the average runoff coefficient of the plain area is calculated to be 0.3. This is in good agreement with the expected results, which proves that the model has certain applicability in the Balihe Lake basin.

INTRODUCTION

The SWAT (Soil and Water Assessment Tool) is a long-term distributed hydrological model developed on the basis of SWRRB model (Arnold and Williams, 1985). It has a strong physical foundation and is suitable for large and complex watersheds with different soil types, land use patterns and management conditions. The SWAT can also be modeled in areas lacking data which is very useful for the areas lacking monitoring data. It is also widely used in Canada and cold regions of North America (Neitsch *et al*., 2011).

Manguerra and Engel (1998) explores a way to improve the accuracy of runoff simulation in areas where data are missing. Luzioand Arnold (2004) simulated 24 representative rainfall events in the Bruhe River basin from 1994 to 2000, and tried to simulate the small-scale function of the SWAT model. Milewki *et al*. (2009) used SWAT model to simulate the runoff in Sinai Peninsula, Egypt, and the eastern desert, and quantitatively analyzed the relationship between runoff and rainfall in the two regions. Chanasyk *et al*. (2003) applied the SWAT model to study hydrology and soil under different land use types, and concluded that the model has the function of precise simulation for watershed with small rainfall. Bekiaris *et al*. (2005) applied SWAT model to simulate the daily and monthly runoff of the river basin, and also achieved good results.

Corresponding author:* **Yixin Xu
Research Center for Engineering Ecology and Nonlinear Science, North China Electric Power University, Beijing, 102206, China

However, the research on runoff simulation started relatively late in China. In early 21st century, Li (2002) studied the Chengshui River Basin in Jiangxi Province, and found the relationship between spatial scale changes and water yield and sediment. Zhang *et al*. (2003) simulated sediment and runoff yield in Lushi watershed for a long period of time on a mesoscale scale, and achieved good results. Wang *et al*. (2003) adopted SWAT model to study the monthly runoff and daily runoff of Yingluoxia sub-basin in the mountainous area of Heihe mainstream, which showed that this model was also applicable to large watershed. Hu *et al*. (2003) simulated the runoff of Luxi small watershed in Jiangxi Province. This result show that the model is accurate in simulating the runoff with a long-time span.

Since the successful development of SWAT model, it has undergone several improvements in the past 30 years, and has made great progress in research depth and application fields. So far, the model has evolved from the original 94 version to the latest 2012 version: since the first introduction of the concept of hydrological response unit in the SWAT94 version, the SWAT model has been gradually improved, adding water quality, fertilizer, rainfall and other modules, and constantly modifying important calculation methods to increase the scope of application. The SWAT 2012 version with complete functions and accurate simulation effect has been formed. In this study, the version used is the 2012 version of SWAT.

Study area and data Acquisition

Study area

The Balihe Lake Basin is located in Yingshang County, southeast of Fuyang City, Anhui Province, China, covering a total area of 241.3km^2. Geographical coordinates are E116°01′-116°38′, N32°54′-32°57′. The study location of the study basin is shown in Fig. 1. It belongs to the transitional climate zone between the north temperate zone and subtropical zone. Due to the interaction of cold and warm air currents in Siberia and the Pacific Ocean and the Indian Ocean, it is hot in summer and cold in winter, with distinct seasons and abundant rainfall, but the distribution is uneven within and between years (Local Chronicle Compilation Committee of Yingshang County, 1995).

Anhui Province, China   Balihe Lake

Fig 1 Location of the Balihe Lake basin

The average annual precipitation in the Balihe Lake basin is 904.6 mm. Influenced by monsoon climate, precipitation varies seasonally and varies greatly between years. Generally, it is more in summer and less in winter, and more in spring than in autumn. In some years, the precipitation intensity was high, and the rainstorm was more and much concentrated. In 1954, the annual precipitation was 1722 mm, twice as much as the annual average precipitation. From June 29 to July 20, 1968, the precipitation in 22 days was 749.8 mm, which was 83% of the average annual precipitation. In 1966, there was only 389 mm precipitation, of which only 0.7 mm precipitation occurred from August to September. Generally speaking, the precipitation is abundant, especially in April to September. June to August is the same season, which is more conducive to the utilization of water and heat resources by crops. However, uneven precipitation is liable to cause different degrees of drought and flood disasters.

The average annual evaporation is 1757.1 mm, which is twice the annual precipitation. Between each month, the evaporation in January was the smallest, averaging 64.0 mm, and in June was the largest, averaging 216.6 mm. In drought and high temperature years, evaporation increased, such as 2169.4 mm in 1966, which was 5.6 times as much as 389.8 mm of precipitation in that year. Such high evaporation results in a particularly uneven water flow in the basin, which often leads to drought.

Acquisition of basic data

The establishment of basic model data requires meteorological data and geographic data. The meteorological data include relative-humidity (fraction), precipitation(mm), solar radiation (MJ/m^2), temperature (℃) and wind (m/s). The above data are from the CMADS (the China Meteorological Assimilation Driving Datasets for the SWAT model. http://westdc.westgis.ac.cn). The time step of those data is day by day, and the time scale is from 2008 to 2016.The geographical data include DEM（Digital Elevation Model 30m*30m), land use, soil and slope. The DEM data set and land use data set are provided by Geospatial Data Cloud site, Computer Network Information Center, Chinese Academy of Sciences. (http://www.gscloud.cn). Soil data is derived from the HWSD (the Harmonized World Soil Database version 1.1) constructed by the Food and Agriculture Organization of the United Nations (FAO) and the International Institute for Applied Systems Analysis (IIASA).

RESULTS AND DISCUSSION

Subbasin division and HRU generation

HRU (Hydrologic Research Unit) is a unique module of the SWAT model (Meng and Wang., 2017). On the basis of subbasin division, combined with land use data, soil species data and slope data, the whole basin was divided into regions with unique combination of land use and soil types. Such HRUs can reflect the differences of hydrological and geological conditions in different regions (Meng *et al*., 2015). In this study, based on the river network generated by DEM data and the export of the selected basin, river network is shown in Fig.2, the area of the Balihe Lake Basin is determined to be 241.3 km^2, and divided into 21 subbasins, the division of subbasins is shown in Fig. 3. At the same time, for the accuracy of the model, the area threshold of HRU was chosen as 20% land use type, 20% soil type and 5% slope type, and finally 99 HRUs were formed.

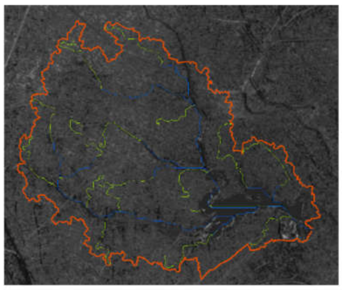

Fig. 2 The river network of Balihe Lake basin

Fig. 3 The division of subbasins in the Balihe Lake basin

Runoff simulation results

Using 2008 and 2009 as preheating years, the runoff data from 2010 to 2016 were simulated. The comparison of monthly mean runoff and rainfall data can be seen in Fig. 4. Through the Fig. 4, we can know that the runoff and rainfall have a strong correlation, the runoff lags slightly, but it conforms to the natural law. The variation laws of the peak and valley for rainfall and runoff were basically the same to a certain extent. The simulation results also showed that the coincidence of the valleys for rainfall and runoff was relatively better than that of the peaks. In 2015, a extreme peak of rainfall and runoff occur, and the simulation results are in relative higher agreement in comparison with those of the other years.

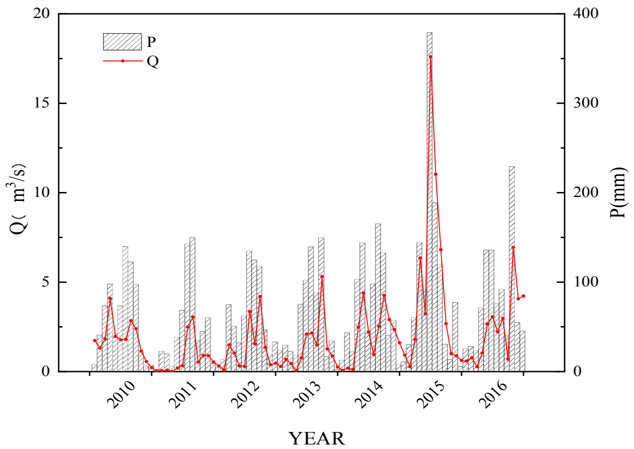

Fig 4 The comparison of monthly mean runoff and rainfall

Fig. 5 is a comparison of runoff coefficient and rainfall. It can be seen that the runoff coefficient of the Balihe Lake Basin fluctuates around 0.3 all year round, but when the year of high water comes. For example, in 2015, the runoff coefficient of the Balihe Lake Basin was only 0.5. According to the data, the average annual evaporation of the Balihe Lake Basin reached 1757.1 mm, twice as the average annual precipitation. It can be seen that the results of the model simulation are in line with the actual situation. The results of this study showed that SWAT model is applicable in the plain water shed of Balihe Lake basin.

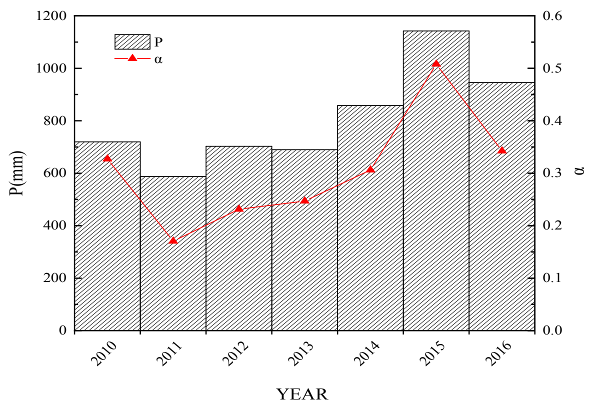

Fig 5 Runoff coefficient and rainfall diagram of the Balihe Lake basin

CONCLUSIONS

In this paper, the SWAT model of the Balihe Lake Basin in Anhui Province is established for the first time by using the available data. The runoff data from 2010 to 2016 are simulated and the runoff coefficient is calculated. According to the actual situation, there is a large area of lake surface in the basin, and the annual average solar radiation is high, which leads to a huge amount of evaporation in the basin. Compared with the actual rainfall input, the runoff coefficients calculated by the model are smaller, floating around 0.3. Even in the year of high water, the runoff coefficients are only 0.5. It can be seen that the model reflects the actual situation very accurately, and the model has good usability.

Acknowledgements

The authors would like to acknowledge with great appreciation for the support provided by the Chinese National Major Science and Technology Program for Water Pollution Control and Treatment (No. 2015ZX07204-007) and the Chinese Fundamental Research Funds for the Central Universities (No. 2017MS065).

Author Contributions

J.L., Y.X. and T.H. were responsible for the research design; J.L., Y.X. and M.Z. drafted the main text and prepared the figures/tables; H.H. provided the financial and logistical support; All authors discussed the results, reviewed and revised the manuscript.

References

Arnold, J. G. and Williams, J. R. Validation of SWRB-simulator for water resources in rural basins. Journal of Water Resources Planning & Management, 1985, 113(2): 243-256. Doi: 10.1061/(ASCE)0733-9496(1987)113:2(243)

Neitsch, S. L.,Arnold, J. G., Kiniry, J. R. and Williams, J. R. 2011. Soil and water assessment tool:theoretical documentation. Temple: Agricultural Research Service,pp. 1-647.

Manguerra, H.B. and Engel, B.A. Hydrologicparameterization ofwatersheds forrunoff prediction using SWAT. JAWRA Journal of The American Water Resources Association, 1998, 34(5):1149-1162. Doi: 10.1111/j.1752-1688.1998.tb04161.x

Luzio, M.D. and Arnold, J. G. Formulation of a hybrid calibration approach for a physically based distributed model with NEXRAD data input. Journal of Hydrology,2004, 298(1-4): 136-154. Doi: 10.1016/j.jhydrol.2004.03.034

Milewski,A., Sultan,M., Yan,E., Becker, R., Abdeldayem, A., Soliman, F. andGelil, K. A. A remote sensing solution for estimating runoff and recharge in arid environments[J]. Journal of Hydrology,2009, 373(1-2):1-14. Doi: 10.1016/j.jhydrol.2009.04.002

Chanasyk,D.S,Mapfumo, E. andWillms, W.Quantification and simulation of surface runoff from fescue grassland watersheds. Agricultural Water Management,2003, 59(2):137-153. Doi: 10.1016/S0378-3774(02)00124-5

Bekiaris, I.G., Panagopoulos, I.N. andMimikou, M. A. Application of the SWAT (Soil and Water Assessment Tool) model in the Ronnea catchment of Sweden. Global NEST Journal,2005,7(3):252-257. Doi: 10.30955/gnj.000343

Li Shuo.Study on Spatial Discretization and Parameterization in Basin Simulation AidedbyRS and GIS and Its Application. Nanjing: Nanjing Normal University, 2002.(In Chinese) Doi: 10.7666/d.Y451255

Zhang, X. S., Hao, F. H., Yang, Z.F. Cheng, H. G. and Li, D. F.Runoff and sediment yield modeling in meso-scale watershed based on SWAT model. Research of Soil and Water Conservation, 2003, 10(4): 38-42.(In Chinese)

Wang, Z. G., Liu, C. M. and Huang, Y. B. Research on the principle, structure and application of SWAT model. Progress in Geography, 2003, 22(1): 79-86. (In Chinese)

Hu, Y. A., Cheng, S. T. and Jia, H. F.. Hydrological simulation in NPS model: case of SWAT in Luxiwatershed. Research of Environmental Sciences, 2003, 16(5): 29-36. (In Chinese)

Local Chronicle Compilation Committee of Yingshang County. Yingshang County Chronicle. Hefei:

Huangshan Publishing House, 1995. (In Chinese) http://60.166.6.242:8080/was40/index_sz.jsp?rootid=35675&channelid=57923.

Food and Agriculture Organization of the United Nations (FAO), International Institute for Applied Systems Analysis (IIASA), ISRIC-World Soil Information, Institute of Soil Science-Chinese Academy of Sciences (ISSCAS), Joint Research Centre of the European Commission (JRC). Harmonized World Soil Database v1.1. Italy: FAO and IIASA.

Meng, X. Y. and Wang, H. Significance of the China meteorological assimilation driving datasets for the SWAT model (CMADS) of East Asia. Water, 2017, 9(10): 765. Doi: 10.3390/w9100765.

Meng,X.Y., Yu,D.L. and Liu,Z.H.Energy balance-based SWAT model to simulate the mountain snowmelt and runoff-taking the application in Juntanghuwatershed (China) as an example.Journal of Mountain Sciences, 2015, 12(2): 368-381.Doi:10.1007/s11629-014-3081-6.

How to cite this article:

Jiazhu Lan *et al* (2019) 'Runoff Simulation Analysis of Swat Model In plain Watershed: A Case Study of Balihe Lake Basin, China', *International Journal of Current Advanced Research,* 08(09), pp.3848.19812.
DOI: http://dx.doi.org/10.24327/ijcar.2019.19809-19812

****