Hydrological modeling of Be River Catchment using CRU TS 3.0 gridded meteorological dataset

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1. Introduction

Effective planning of water resource use and protection under changing conditions requires the use hydrological models that can simulate the hydrological processes within the basin under different change scenarios. In hydrological modeling, the meteorological data evaluated are the most important parameters. In some countries and basins, the meteorological data are limited or discontinuous because of many different reasons such as lack of technology, war, and financial limitations. A variety of gridded datasets of meteorological observation exists that can handle this problem including CRU (Climate Research Unit, from University of East Anglia, UK), GPCC (Global Precipitation Climatology Centre), and GPCP (Global Precipitation Climatology Project). The objective of this study is to test the usefulness and suitability of the application of gridded CRU-TS3.0 dataset in hydrological modeling for Be River Catchment, Vietnam.

2. Study area

Be River Catchment lies between latitudes 11°10' to 12°16' N and longitudes 106°36' to 107°30' E (Fig. 1). It has a catchment area of about 7500 km^2. The altitude varies from 1000m in the highland area to 100m in the plain area with the direction from northeast to southwest and south. The climate is tropical monsoon. The annual rainfall varies between 1800 and 2800 mm with an average of 2400 mm. This area has two seasons: the rainy and dry seasons. The rainy season lasts from May to November and accounts for 85 to 90% of the total annual precipitation. The catchment has been assessed as having the most abundant water resources in Dong Nai River Basin and large hydropower potential.

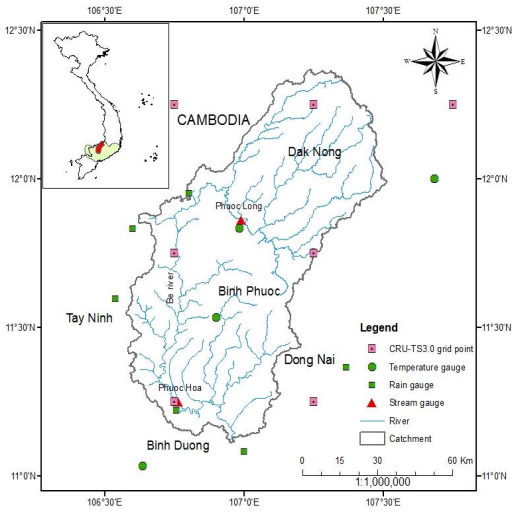

Fig.1 Location map of Be River Catchment

3. Methodology

The Soil and Water Assessment Tool (SWAT) model is a physically based, semi-distributed, basin-scale, continuous time hydrological model that operates on a daily/sub-daily time step. In SWAT, a watershed is divided into a large number of sub-watersheds that are then subdivided into unique soil/land-use characteristics called hydrological response units (HRUs) that allows a high level of spatial detail simulation. The model simulates the hydrology at each HRU using the water balance equation. Further details can be found in the SWAT Theoretical Documentation (Neitsch et al., 2011).

The SWAT model inputs consist of DEM, land-use map, soil map, and climatic data. Climate data for the catchment include monthly minimum and maximum temperature, precipitation and number of wet days were obtained from the gridded (0.5° x 0.5°) CRU-TS 3.0 observational dataset (Mitchell and Jones 2005). Monthly data for 7 grid cells (Fig. 1) which cover the catchment were disaggregated to a daily data using a weather generator (MODAWEC model, Liu *et al.* 2009).

Monthly stream flow data measured at Phuoc Long and Phuoc Hoa gauging stations (Fig. 1) were obtained from Vietnam Hydro-Meteorological Data Center from 1981 to 1990 using for calibration and validation purposes. The model set-up involved five steps: (1) data preparation, (2) sub-basin discretization, (3) HRU definition, (4) parameter sensitivity analysis, and (5) calibration and validation.

Keywords: Be River Catchment, CRU-TS 3.0 data, Hydrology, SWAT model
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4. Result and discussion

The most sensitive parameters were CN2, ESCO, GWQMN, ALPHA_BF, SOL_Z, SOL_AWC, CH_K2, GW_REVAP, CH_N2, and SOL_K. These parameters were identified from 27 parameters in simulation of streamflow within SWAT model using the automated sensitivity analysis procedure within the SWAT model, and adjusted from the SWAT initial values to fit the simulated streamflow with the observed flow.

The SWAT flow predictions were calibrated against monthly flow from 1981 to 1985 and validated from 1986 to 1990 at Phuoc Long and Phuoc Hoa gauging stations. Figure 2 shows monthly hydrographs derived from the model using both the observed meteorological data and CRU dataset at both flow gauging stations. The simulated monthly flow based on station-based data matched well the observed data for both calibration and validation periods at Phuoc Long and Phuoc Hoa stations with values of NSE, PBIAS, and RSR as shown in Table 1. In case of using CRU dataset, model performance over the calibration and validation periods is generally good as indicated by acceptable values of NSE, PBIAS and RSR at Phuoc Long and Phuoc Hoa station (see Table 1). Generally, the peak flow was underestimated in simulation based on both the CRU dataset and the observed meteorological data, and agreement between the observed and simulated discharge using CRU data as input is not good compared with that obtained using the observed meteorological data. However, the simulated flow using CRU dataset can be considered reasonable.

Tab. 1 Model performance for streamflow simulation based on CRU data and rain gauge data at Phuoc Long and Phuoc Hoa stations

Gauging station	Period	Observed	Simulated based on station-based data				Simulated based on CRU TS data			
		Mean (m^3/s)	*Mean* (m^3/s)	*NSE*	*PBIAS* (%)	*RSR*	*Mean* (m^3/s)	*NSE*	*PBIAS* (%)	*RSR*
Phuoc Long	Calibration	101	94	0.86	-6.69	0.37	94	0.63	-6.31	0.60
	Validation	106	96	0.85	-8.90	0.38	97	0.55	-7.67	0.67
Phuoc Hoa	Calibration	202	212	0.91	-4.75	0.30	194	0.76	-8.52	0.49
	Validation	228	231	0.93	-3.35	0.27	199	0.67	-15.72	0.57

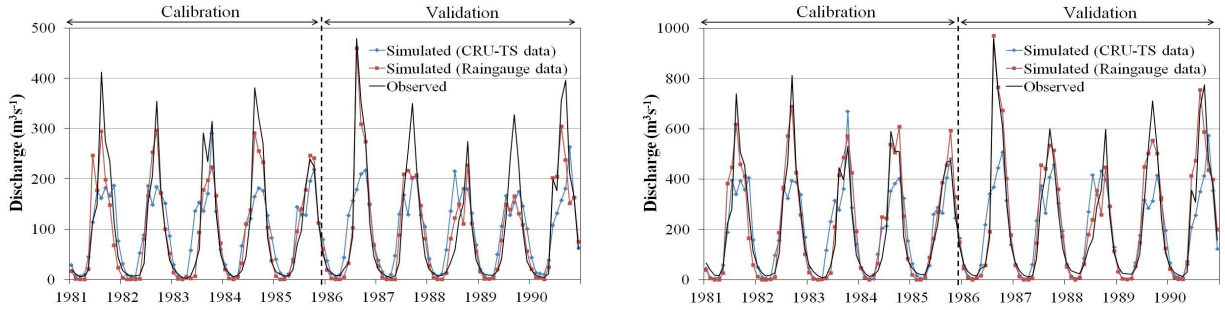

Fig. 2 Monthly discharge at Phuoc Long (left) and Phuoc Hoa (right) gauging stations for calibration and validation period

5. Conclusion

From the results of calibration and validation, it is indicated that SWAT model is a reliable hydrological model to simulate the hydrological processes for this catchment. Another result suggests that gridded CRU climate dataset may be used to replace the observed data in hydrological modeling of Be River Catchment as well as data-sparse areas.

Acknowledgement

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