Estimation of runoff and snowmelt in forested area in snowy region using SWAT

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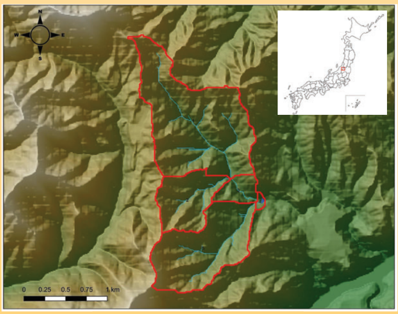
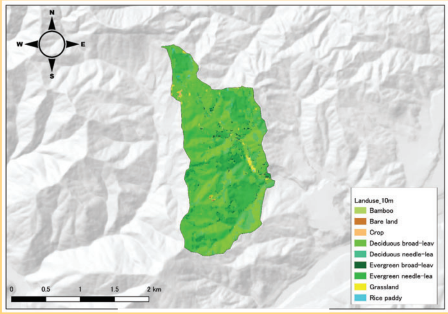
1. INTRODUCTION

- SWAT model, which utilizes fewer parameters and less input data, is currently used to evaluate distributed snowmelt and runoff formation in snow watersheds(Duan et al., 2018).SWAT (Soil and Water Assessment Tool) developed by USDA-ARS is a model that has been used worldwide for more than 20 years (Williams et al., 2008). In place where data is difficult to obtain, using SWAT+ to make long-term predictions is an effective method. In order to face present and future challenges in water resources modeling SWAT code has undergone major modifications over the past few years, resulting in SWAT+, a completely revised version of the model. (Bieger et al., 2016).
- Two type of model which were the adjusted parameters from the default parameter and the automatic calibration of SWAT+ were made to improve the accuracy of the model. The accuracy of the model was verified by comparing with the observed data.



A. Elevation Data



B. Land-use Data

Fig1：Hashigo River of Mishima town in Fukushima Prefecture（28.5km）

2. METHODOLOGY

- Spatial and Temporal Data

The SWAT model was built from the spatial and Temporal data (Table.1)

- Adjusted Parameters

Default values were used for SWAT parameters, except for the following adjustments.

1) Snow melt (Melt_tmp) and Snowfall temperature

The default values did not reproduce the amount of snowmelt well, Snow melt (Melt_tmp) and Snowfall temperature (Fall_tmp) were calculated from the measured data.

2) hydraulic conductivity (Soil_k) and the available water capacity of soil layer (Awc)

Soil_k and Awc were adjusted using the soil data of each prefecture surveyed and published by the National Institute of Agrobiological Sciences and modified.

- Auto Calibration

The auto-calibration can be selected from NSE, RMSE and MSE to improve, and in this study, NSE was selected for the calibration of the time of lateral flow travel (lat_time) was calibratedSimulation period

The warm-up period was 1 year and simulation period from February 2019 to December 2020.

Table.1：Spatial and Temporal Data

Data	Source	Note
Elevation data	Geospatial Information Authority of Japan (GSI)	Raster data (10m mesh)（Fig.1 A）
Land Use	the Japan Aerospace Exploration Agency (JAXA) and Earth Observation Research Center (EORC)	10m mesh <Land use: 12 categories>. Land use was confirmed by foot survey, and some obviously different land uses were corrected.（Fig.1 B）
Soil map	the National Institute of Agrobiological Sciences (NIAS)'s basic land classification survey data (Shapefile, 1:200,000)	Shapefile (Polygon)
Weather data	Field observation conducted by a project team in National Institute for Environmental Studies of Japan (NIES)	10 min Data: Flow rate (m^3/s) Daily data: Rainfall, Temperature(Max, Min, Avg), Relative Humidity, Solar Radiation, Wind Speed

3. RESULTS AND DISCUSSION

1) Simulation of Daily Flow Rate

In the first calculation, the default values of SWAT database were used for the parameters, and the calculation period was set to 2019-2020. The calculation results are shown in Fig. 2. The peak flow rate during the rainfall event is higher than Observed value. In addition, the flow rate during snowmelt events (From February to April) is lower than Observed data, and the snowmelt rate is not reproduced.

2) Adjusted parameter and Auto Calibration

The results of adjusting the parameters and the results of automatic calibration of lat_time are shown in Fig. 3. The river discharge after the calibration within February to April was closer than the first simulation to the observed data. The calibration slowed the decrease in the river discharge after the peak of flow and increased the correlation between simulated and observed values.

3) Accuracy

a. RMSE

The RMSE for each month were calculated from the simulation results of Default parameter, Adjusted parameter, and Auto-Calibration. The results are shown in Fig. 4. During rainfall events, the value of RMSE is high and the accuracy is evaluated to be low. During low rainfall events, the river discharge is low and the accuracy is better because the difference between observed and predicted values become smaller.

b. NSE

The NSE for each month were calculated from the simulation results of Default parameter, Adjusted parameter, and Auto-Calibration. The results are shown in Fig. 5. During rainfall events in the rainy season, snowfall season (Dec-Feb) and snowmelt season (Mar-Apr), the value of NSE is low, indicating low accuracy. The accuracy of the Adjusted parameter and Auto-Calibration were shown to be improved over the Default parameter in NSE.

The whole period of RMSE and NSE are shown in Table.2

Table.2：RMSE and NSE for Whole Period

Entire Period	Default Parameter	Adjusted Parameter	Auto-Calibration
RMSE	0.23	0.19	11.19
NSE	-1.03	-0.35	-0.33

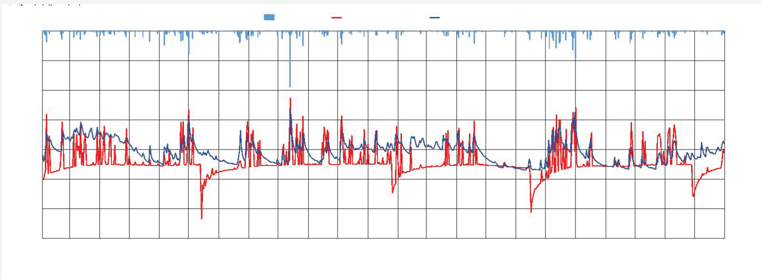


Fig.2：The Simulation Value of the Default Parameter

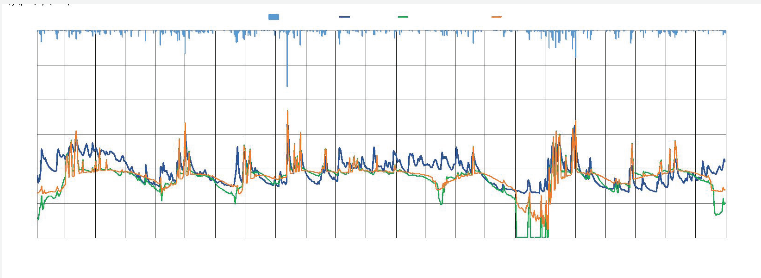


Fig.3：The Simulation Value of the Adjusted Parameter and Auto Calibration

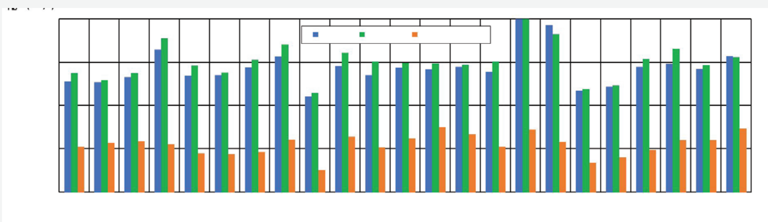


Fig.4：The Monthly RMSE for Each Simulation

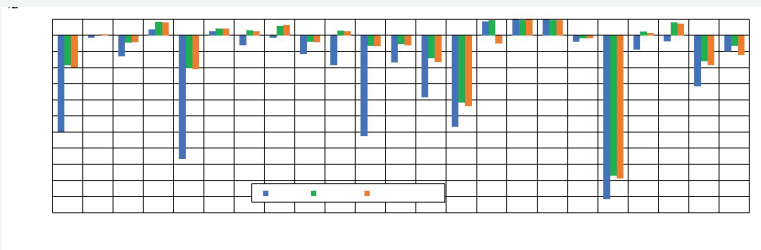


Fig.5：The Monthly NSE for Each Simulation

4. CONCLUSION

Using SWAT+, we constructed a river flow prediction model for the Hashigo River, and found the following;

1. The accuracy of the simulation could be improved to some extent by adjusting the parameters.
2. The reproducibility of groundwater discharge was tried to improve by adjusting the value of lat_time by the automatic calibration, but it was difficult to obtain significant improvement.
3. The accuracy of the simulation may be improved by using the actual measurement of soil data, because the actual measurement of soil data was not obtained in this study.
4. However, the simulation of snowfall and snowmelt in mountainous forest areas requires careful adjustment of SWAT+ parameter settings due to the complexity of conditions such as different elevations and slopes.
5. In this study, the auto-calibration improved the NSE value, but the RMSE value worsened.
6. The auto-calibration can select and improve the value of NSE, RMSE, and MSE, but it