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EXTENDED ABSTRACT

Multi-station Calibration of Snowmelt Runoff Model (SRM) Using Remote Sensing Tools in Aji-Chay Basin, Iran

Vahid Nouran*, Amin Afkhaminia, Soghra Andaryani

Faculty of Civil Engineering, University of Tabriz, Tabriz, Iran

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1. Introduction

Global warming and climate change affect the depletion of available water resources and limited access to new resources in recent years. Due to these issues, the essential of managing water resources feels more than ever. Water resources have been one of the most important topics in recent years, and many types of researches have been done so far (Rulin et al., 2008). Snow is one of the essential factors in maintaining and sustaining people's livelihood. The snowmelt runoff model (SRM) is a degree-day-based method. The SRM was presented to calculate the snowmelt impact on watershed daily runoff (Martinec, 1975). The SRM was successfully applied in some basins to simulate melt season runoff (Zhang et al., 2014; Tekeli et al., 2005). Multi-station calibration has been used in this study that is a useful way to overcome the limitations of Single-site calibration strategy (e.g., large-scale basins with much spatial variability).

2. Methodology

2.1. Data acquiring

The SRM needs three inputs to run: a) temperature, b) precipitation, and c) the snow-covered area (SCA) on a daily scale. Using remote sensing tools or ground observation stations data are two primary ways to provide these variables. The MODIS snow data was used in this study to calculate the SCA that is a substantial input in the SRM. These data have various levels that have been divided into different temporal resolutions, i.e., daily, 8-day, and monthly average. Also, these images are driven from the Normalized Difference Snow Index (NDSI) algorithm, which uses MODIS reflectance bands 4 and 6, according to Eq. (1) (Hall and Riggs, 2007):

$$NDSI = \frac{Band\ 4 - Band\ 6}{Band\ 4 + Band\ 6} \tag{1}$$

2.2. Snowmelt runoff model (SRM)

The SRM is a degree-day model; in this kind of model, the temperature is the principal element to advocate melting in mountainous regions. According to the Eq. (2), the SRM is used to simulate and forecast runoff by the contribution of snowmelt and rainfall (Martinec et al., 2008):

$$Q_{n+1} = \underbrace{C_{Sn}\,.\ a_n(T_n + \Delta T_n)S_n\,.\ A\,.0.116(1 - k_{n+1})}_{\text{snowmelt runoff}} + \underbrace{C_{Rn}P_n\,.A\,.0.116(1 - k_{n+1})}_{\text{rainfall-runoff}} + \underbrace{(Qs_n + Qr_n)k_{n+1}}_{\text{runoff contribution from the previous day}} \tag{2}$$

* Corresponding Author
*E-mail addresses*nourani@tabrizc.ac.ir (Vahid Nourani), *:* a.afkhami97@ms.tabrizu.ac.ir (Amin Afkhaminia), s.andaryani@gmail.com (Soghra Andaryani).

Where Q is the mean daily discharge (m3/s); C is the snow (Cs) or rain (Cr) runoff coefficient; a is the degree-day factor (DDF) (cm °C-1 d-1); T is number of the degree-day (°C d); ΔT is the temperature adjustment factor (°C d); S is the ratio of the snow-covered area to the total area; P is precipitation contributing to runoff (cm); A is the area of basin or elevation zone (km2); n is the sequence of days during the discharge computation period, and k is the recession coefficient (Xc and Yc). The most uncertain parameters are the runoff coefficients (Cs and Cr), so they have been implemented to calibrate the model with both of the mentioned calibration strategies (Multi-station and Single-site).

3. Results and discussion

3.1. Elevation zones and SCA

To improve the efficiency of the SRM, the study basin has been divided into different elevation zones by DEM. This feature has an essential capability concerning the height, which affects the temperature variable and modifies its accuracy. Therefore, the basin has been shared into five elevation zones with a 500m increment in each zone. The case study has been divided into two sub-basins to use in the multi-station strategy.

SCA is the most important parameter to run the model. MODIS 8-day snow cover images (MOD10A2) have been used to compute the SCA by ENVI and ArcMap programs. SRM needs daily data. Therefore, linear interpolation has been applied to transform the 8-day temporal resolution to a daily scale.

3.2. Simulation of SRM

The model was run for five hydrologic years, four years (2008-2011) for calibration, and one year (2012) for validation. Results show that multi-station calibration improves the accuracy of the model. Fig. 1 illustrates the hydrograph of simulation runoff and measured runoff for both calibration strategies.

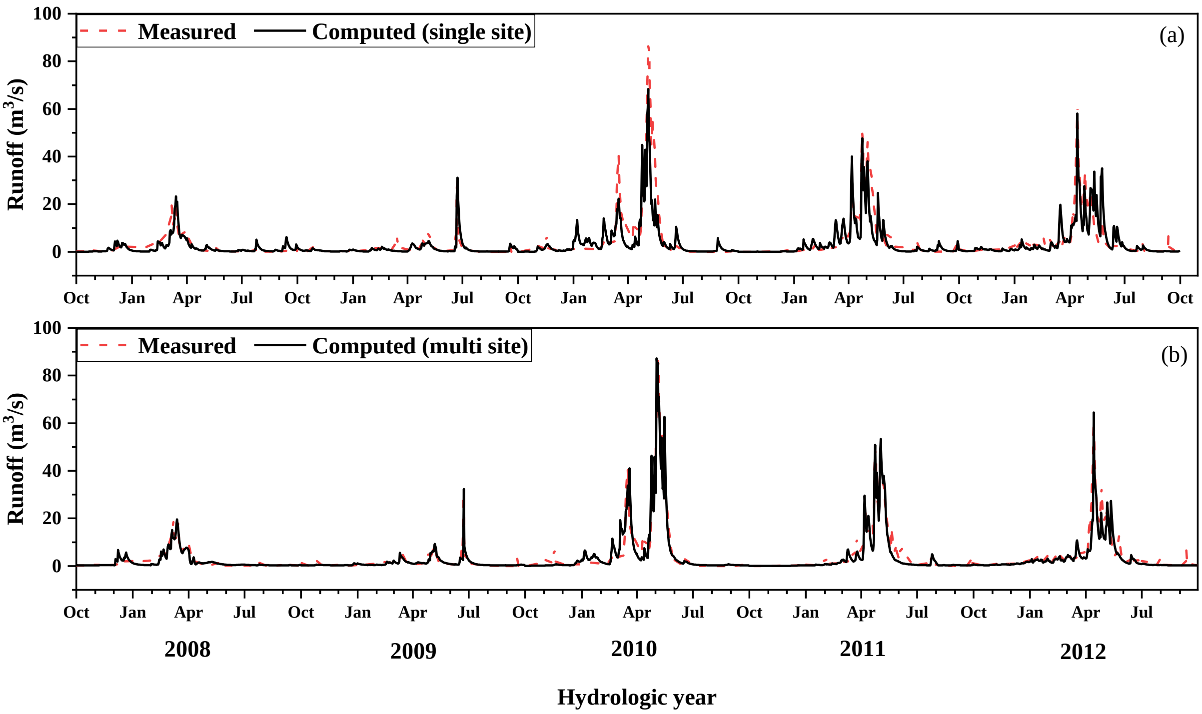

Fig. 1. Hydrograph of Measured and computed runoff for: a) Single-site, b) Multi-station strategies (2008-2012)

According to Fig. 1, the peak runoffs' simulation accuracy in multi-station calibration strategy is more than single-site calibration strategy. Computed daily snowmelt, which impacts runoff, is the critical part of this model; thus, snowmelt contribution is an average of 40%. The multi-station calibration provided more proportion of snowmelt rate in comparison with the single-site strategy.

4. Conclusions

The results outline that the SRM has an appropriate ability to simulate and forecast the daily runoff contributing to the snowmelt, and the temperature is a proper element to calculate the daily snowmelt rate.

The MOD10A2, which has 8-day temporal resolution, has been used for gathering the snow-covered area. Results show that this product is reliable for the Aji-Chay basin.

5. References

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