ウェーブレット変換による下部ミャンマーの水文・気象データの解析

Analysis of hydro-meteorological data in lower Myanmar based on wavelet transform

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1. Introduction

In water resources planning and management, it is vital to analyse the characteristics of the hydro-meteorological data because of the highly variability in temporal and spatial scales. The objectives are to detect the features of rainfall and inflow data at different temporal scales based on a wavelet transform. Wavelet transform is a method of converting a function (or signal) into another form, which enables the original data set to be described more succinctly [1].

In this research, we applied a continuous wavelet transform method on two hydro-meteorological data, observed in lower Myanmar, which is in the tropical monsoon region of Southeast Asia. The basic concept of the continuous wavelet transform is to achieve a complete time-scale representation of localized and transient phenomena occurring at different time scales [2].

2. Method and materials

The wavelet transform of a continuous signal $x(t)$ with respect to the wavelet function, $y(t)$, is defined as:

$$T(a,t) = \frac{1}{\sqrt{a}} \int_{-\infty}^{\infty} x(t)\, y^{*}\left(\frac{t-t}{a}\right) dt \qquad (1)$$

where

$$y_{a,t}(t) = \frac{1}{\sqrt{a}}\, y\left(\frac{t-t}{a}\right) \qquad (2)$$

The function $y(t)$ can be the real or complex function, is called a wavelet. The asterisk corresponds to the complex conjugate. T indicates as the wavelet transform function, a as dilation parameter, t as location parameter, y^{*} as the complex conjugate of the wavelet transform.

The continuous Morlet wavelet function is presented as:

$$y(t) = \frac{1}{\sqrt{2p}} \exp(2ip\, f_c\, t) \cdot \exp\left(-\frac{t^2}{2}\right) \qquad (3)$$

where i is complex number, f_c is wavelet center frequency, in this case $f_c = 0.5$.

The applied data are daily rainfall data and daily inflow data of Ngamoeyeik reservoir, which locates in lower Myanmar [3]. The data were observed over a period of 5 years, from 1996 to 2000. Daily rainfall data were recorded at the dam site and inflow data were observed at the reservoir site.

In the pre-processing of analyses, some considerations were taken for the observed data, which were sampled at one-day- interval and finite time lengths.

3. Results and discussions

The results obtained are presented in Fig.1(a) to (c). Fig. 1(a) shows the original rainfall data. Fig. 1(b) and (c) show the images of modulus and angles of wavelet transform from 1(a), respectively. The horizontal axis represents time in day and the vertical axis

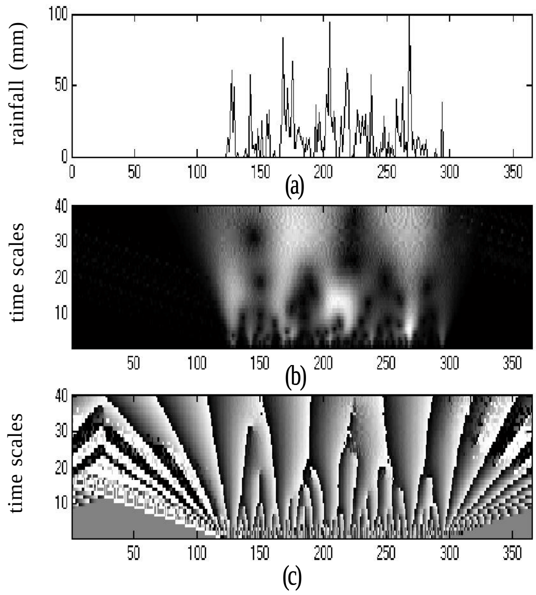

Fig.1. (a), Original signal, daily rainfall in 1996; (b), Modulus of the transform; (c), Angles of the transform

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represents time-scales. The time-scales are presented in a maximum of 40 days so as to cover one-month period.

Fig. 2(a)-(b) and Fig. 3(a)-(b) show the contour plots of modulus of wavelet scalogram of rainfall (R) and inflow (Q) for two years, respectively. The contour thresholds, which are in light gray blobs, reveal two information in temporal scales on the original data (R) (Fig. 2(a) and 3(a)). They are: (i) the locations of relatively high rainfall events, which occurred at 140, 180, 220, 240 and 270 days in Fig. 2(a), and at 160, 180 and 215 days in Fig. 3(a); (ii) The feature time-scales of these events, which around 5 and 20 days in Fig. 2(a), and 5 and 15 days in Fig. 3(a).

Similarly, in the case of (Q), the locations of relatively large inflows and their time-scales can also be seen in Fig. 2(b) and 3(b). The high rainfall and large inflow events in 1998 are comparatively less than that of in normal years (Fig. 2(a)-3(a), 2(b)-3(b)). It is because the annual rainfall in 1998 is 1830 mm, which is less than average annual rainfall 2400 mm.

Two hydrological characteristics of R and Q are observed from the modulus of wavelet transform. (1) The number of occurrences of Q is less than R due to the rainfall losses in runoff process. (2) The variations in Q are lower than in R because the behavior of Q is continuous while which of R is intermittent.

Fig. 2(c) and 3(c) show the line plots of the modulus on the data R and Q, which are extracted at 10-day-scale. In both graphs, the modulus line for Q are lagged behind R. It shows that the inflow does not occur from 120 to 150 day, in the beginning of rainy season. The locations of peaks in Q and R are nearly in same positions between 200-250 day in Fig. 2(c) and 170-190 day in Fig. 3(c). It shows that the events of R and Q occur at nearly same day of R after an initial rainfall loss.

4. Summary

The temporal variability of R and Q data can be clearly seen in different time-scales using the wavelet transform. Wavelet transform method is effective for time scale and frequency analysis on the hydro-meteorological data in developing water resources planning and management.

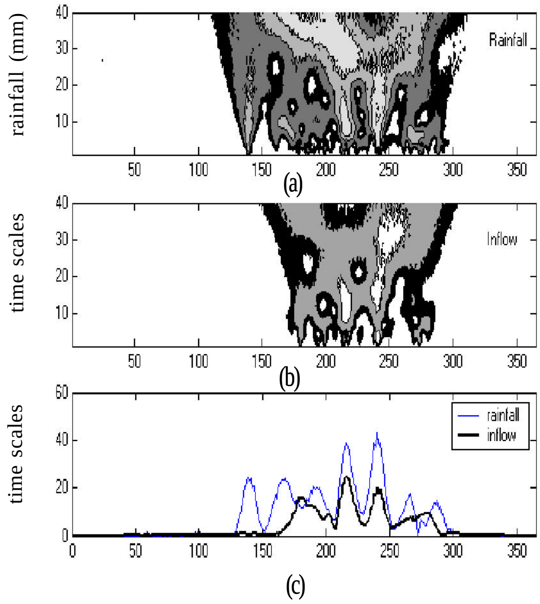

Fig.2 (a)-(b),Continuous Morlet wavelet modulus of daily rainfall (R) and inflow (Q) in 1997; (c), Coefficients of (R) and (Q) at 10 day scale in 1997

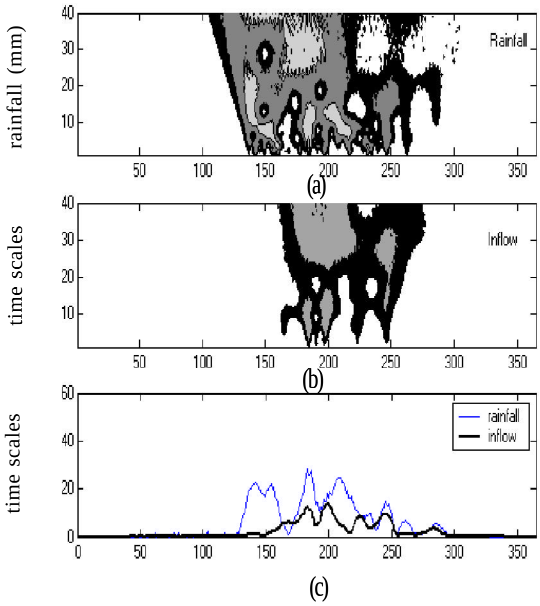

Fig.3 (a)-(b),Continuous Morlet wavelet modulus of daily rainfall (R) and inflow (Q) in 1998; (c), Coefficients of (R) and (Q) at 10 day scale in 1998

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