Rainfall Distribution Pattern Investigation with Unit Disaggregation Curve (UDC) Technique

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Abstract

The technique of Unit Disaggregation Curve (UDC) has been developed in this study in order to investigate the pattern of rainfall distribution within a year. The proposed technique is based on the concept of Disaggregation model. UDC is constructed from the historical rainfall records, which have been identified as signal. The data used in the study are the records from 4 stations distributed over Northeastern of Thailand, of which the length of records is at least 50 years. Applying wavelet to those signals, approximations or trend, and details or noise, are separated. The analysis emphasizes on the approximations that apparently demonstrate similar pattern of distribution in each year. The rainfall distribution pattern graphs of each year are recognized from these approximations. The obtained UDC is generated from the representative pattern of rainfall distribution graph within a year. The UDC is expressed in the unit curve that is able to apply for any level of annual rainfall. By coupling the signal of details, the further study can be undertaken to develop the new technique of rainfall prediction process.

Keyword: wavelet, rainfall, disaggregation

1. Introduction

Rainfall is the most significant parameter for water resources planning; especially in plantation planning, not only amount of rainfall but also the distribution of rainfall within a year is need. Several stochastic models have been proposed for modelling hydrologic time series for long time such as autoregressive model (AR) (Yevjevich,1963), fractional Guassian noise model (Matalas and Willis, 1971) and autoregressive moving-average models (ARMA)(Carlson et. al.,1970) etc. The objective of this study is to develop a technique that can investigate the rainfall distribution within a year, which is a part of rainfall prediction model. The analysis was undertaken with rainfall records of 4 stations distributed over Northeastern part of Thailand by applying wavelet analysis with rainfall records and constructing a Unit Disaggregation Curve (UDC). Figure 1 shows the location of the studied stations.

The proposed UDC can demonstrate the characteristics of rainfall distribution within a year in term of trend that noises already eliminated and the curve also is convenient to utilize as disaggregation tool for rainfall prediction.

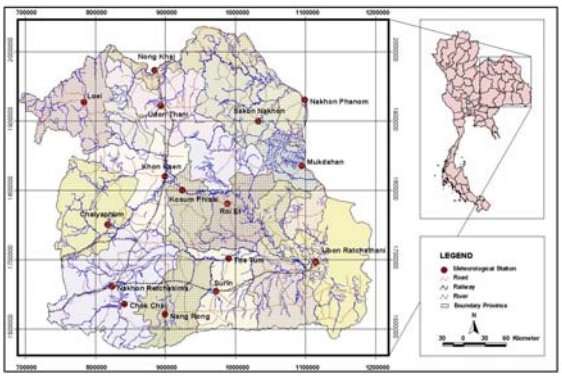


Fig.1: The 4 Studied stations(Khon Kaen, Nakhon Ratchasima, Ubon Ratchathani and Udon Thani.)

2. Wavelet and Disaggregation model application for Unit Disaggregation Curve (UDC)

As wavelet can be easily applied for signal analysis, this study used wavelet to separate the details (noises) from the approximations (trend) of rainfall records. In wavelet analysis, the approximations are the high-scale, low-frequency components of the signal, and the details are the low-scale, high-frequency components. The process of 3-layer decomposition with wavelet is demonstrated in Fig.2 as wavelet decomposition tree. The decomposition process can be iterated, with successive approximations being decomposed in turn, so that one signal is broken down into many lower resolution components. The wavelet decomposition can yield valuable information of signal.

In order to eliminate the details from the approximations in this study, the decomposition process of wavelet was applied to rainfall records, which was identified as a signal process. The obtained approximation curve will apparently demonstrate characteristics of rainfall distribution within a studied year. UDC technique was developed from the basic concept of linear disaggreagtion model that subseries of monthly data sum exactly to key series of annual data.

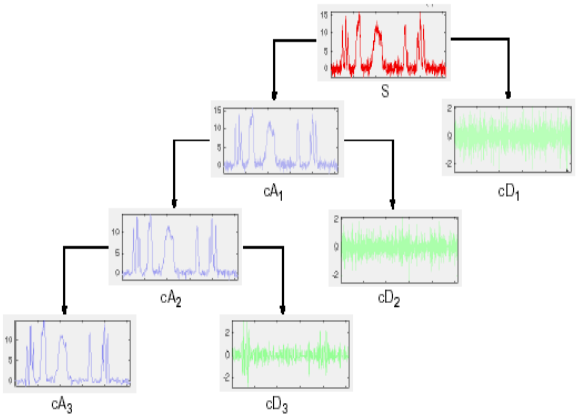


Fig.2: Wavelet decomposition tree

The basic linear dependence model (Valencia and Shaake, 1973) that has been applied to this study is

$$Y = AX + B\varepsilon \quad (1)$$

Where Y is the current observation of the series being generated (subseries or dependence series which is monthly series in this case); Y is generated dependent on X series (key series or independent series which is annual series in this case).; ε represent the current value of a completely random series (stochastic term which is separated as details).

The process of UDC construction is shown in Fig. 3.

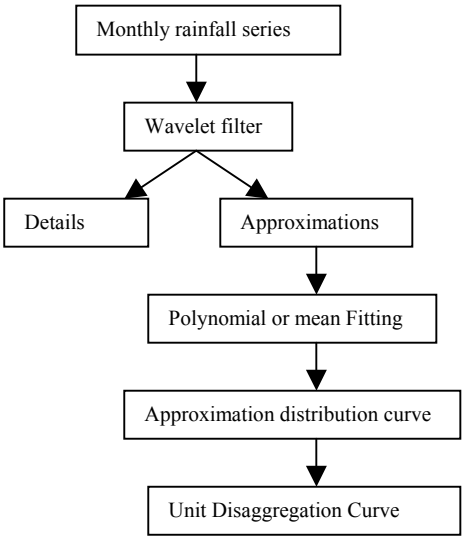


Fig.3: The UDC construction process

3. Studied Data

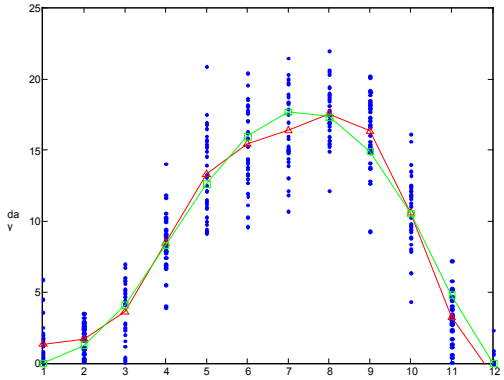
The selected 4 rainfall stations distributed over Northeastern part of Thailand were tested in this study. The records range of monthly and annual rainfall of these stations is at least 50 years. The information of records is shown in Table 1. The studied process was tested with 2 variables series of the number of rainy days (day) and the amount of rainfall (mm).

Table 1 Details of rainfall records of the 4 stations

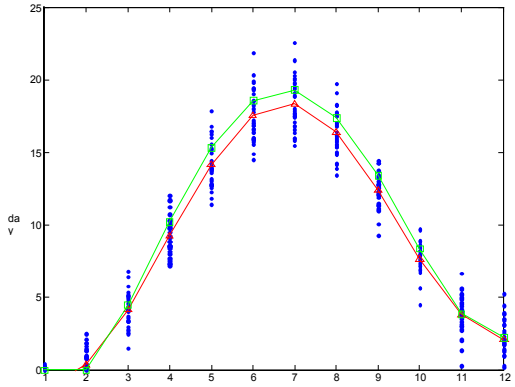
Station	Year	Latitude – longitude	No. Year of record	Avg. Rainfall (mm)	Mean number of wet days
Khon Kaen	1951 - 2002	16.26N 102.50E	52	1212.5	87.21
Nakhon Ratchasi-ma	1951 - 2002	14.58N 102.05E	52	1092.6	86.73
Ubon Ratcha-thani	1951 - 2002	15.15N 104.52E	52	1580.8	100.88
Udon Thani	1951 - 2002	17.23N 102.48E	52	1460.3	101.42

4. Results

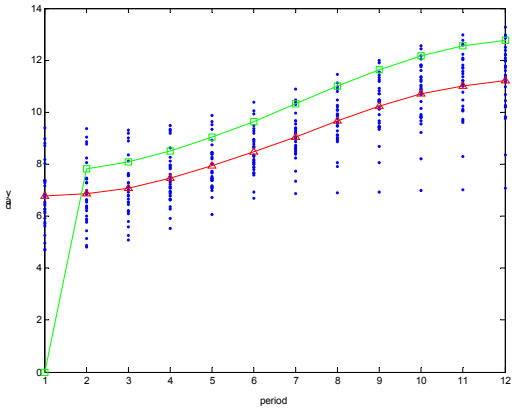
By analyzing with 1-3 level of wavelet filter, it is found that the obtained approximation distribution curve of 2-level filter is the most appropriate to illustrate pattern of distribution as Fig.4. Considering the curve obtained from 3-level filter, some information of approximations is separated and included into the details as shown in the curve of details in Fig.5(c).



(4a) 1 level-wavelet filter



(4b) 2 level-wavelet filter



(4c) 3 level-wavelet filter

Fig 4: Approximation Distribution Curve of Number of rainy days of Khon Kaen station. (red line: Arithmetic mean and Green line: Polynomial fitting)

From the approximation curve of 2-level filter, the UDC was constructed by cumulating each

month variables into annual value and made it into a unit curve. The example of unit curve of UDC for number of rainfall are shown in Fig.6. Similarly, 2-level filter is also appropriate for investigate the approximation distribution curve of monthly rainfall (mm). Fig.7 and Fig. 8 show the curves of rainfall distribution of Udon Thani station and the UDC of rainfall of Ubon Ratchathani station, respectively.

5.Conclusion

Studying with 4 rainfall stations data records, the obtained UDC from analyzing of rainfall and number of rainy days can illustrate the pattern of distribution within a year very well. The UDC is expressed in the unit curve that is able to apply for any level of annual rainfall. The UDC technique is the first step of wavelet-disaggregation model for rainfall prediction. Further study is undertaken to construct the rainfall prediction model that can predict annual rainfall and monthly rainfall within a predicted year.

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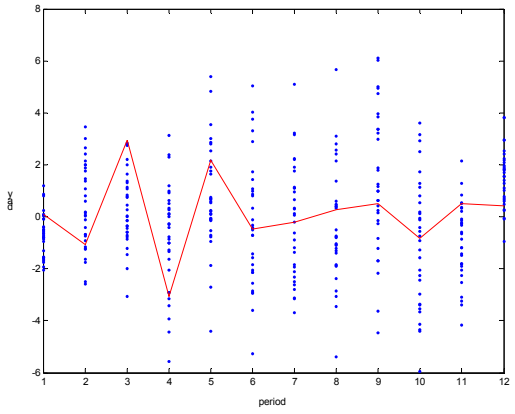
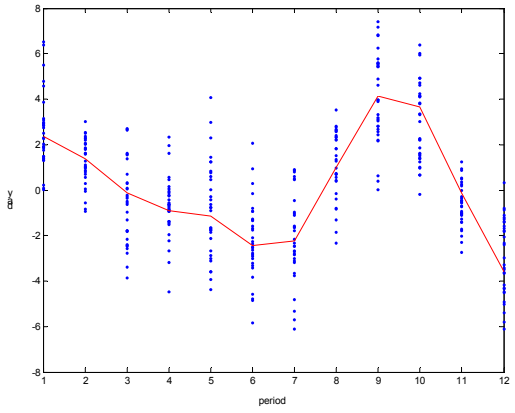
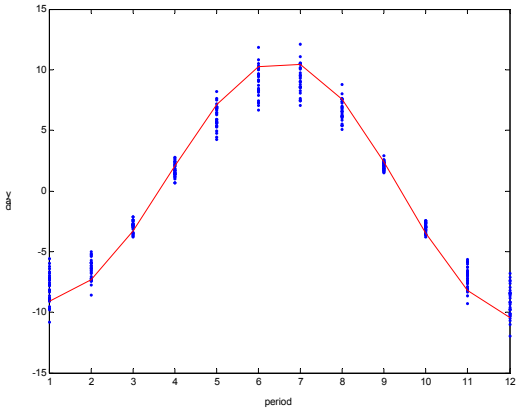


(5a) 1 level-wavelet filter



(5b) 2 level-wavelet filter



(5c) 3 level-wavelet filter

Fig 5: Details curve of Number of rainy days of Khon Kaen station.(red line: AR generated sequences)

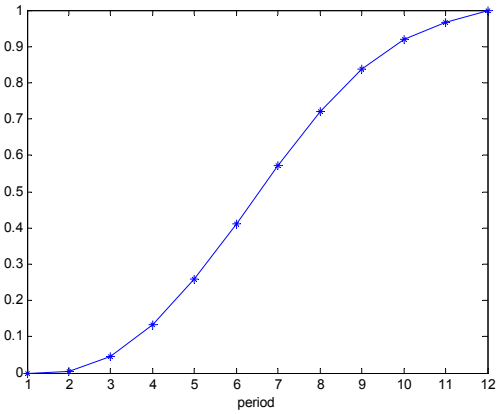


Fig 6: The UDC of number of rainy days of Nakhon Ratchasima station

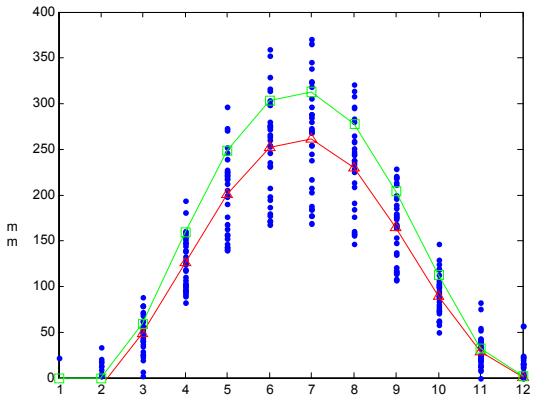


Fig 7: The 2-level approximation distribution curve of rainfall (mm) of Udon Thani station. (red line: Arithmetic mean and Green line: Polynomial fitting)

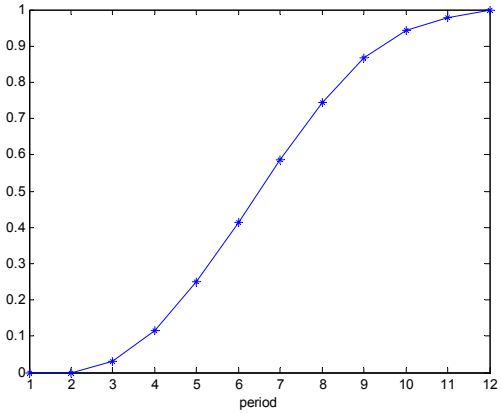


Fig 8: The UDC of number of rainfall (mm) of Ubon Ratchathani station

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