(II −68) **Cross-correlation between Southern Oscillation Index (SOI) and precipitations in AP FRIEND region**

Yamanashi University, Member, Z. X., Xu[1]
Yamanashi University, Member, K., Takeuchi
Yamanashi University, Member, H., Ishidaira

1. Introduction

The main purpose of this paper is to detect and identify the possible impact of climatic change on hydrological processes that may have occurred in Southeast Asia and the Pacific region, and to investigate the correlation relationship between the precipitations and the Southern Oscillation Index (SOI) time series in the study area. The long-term monotonic trend of SOI time series is detected by using nonparametric Mann-Kendall statistical test, and the cross-correlation relationship between the precipitation and SOI time series is examined using both nonparametric Kendall test and parametric Pearson correlation approach through the available precipitation records in 8 Southeast Asia and the Pacific FRIEND countries over the past century.

2. Model Description

The nonparametric Mann-Kendall method is a widely employed approach for testing trends in hydrological processes (Burn, 1994). Besides the high power for detecting the trend of time series, it is also noteworthy for its capability to estimate the magnitude of the trend. The Kendall slope, defined as the median over all combination of record pairs for the whole data set, is an unbiased estimator of trend magnitude. A positive value of β indicates an 'upward trend', i.e. increasing values with time, and a negative value of β indicates a 'downward trend', i.e. decreasing with time. Kendall test is also efficient for correlation analysis, and a general measure of correlation between two time series is the Kendall's τ (tau). The hypothesis of no correlation (independence) is performed by calculating τ_a and τ_b (τ_b handles ties) on the basis of the Kendall sum S, that are given as follows,

$$\tau_a = \frac{S}{n(n-1)/2} \tag{1}$$

$$\tau_b = \frac{S}{\sqrt{(D-T_x)(D-T_y)}} \tag{2}$$

in which D=n(n-1)/2 and

$$T_x = \sum_i t_i(t_i - 1)/2 \tag{3}$$

in which t_i is the number of ties in the x variable with the i-th tie value. T_y is calculated in a similar manner.

3. Result Analysis and Discussion

In this study, the precipitation records are employed to verify the long-term characteristics of hydrological time series and to detect the impacts of climatic change. All catchments cited in Catalogue of Rivers vols. I, II, and III are examined, which resulted in 30 rivers to be contained in the dataset with a range of record lengths from 24 to 102 years and with a mean length of 44 years. The annual precipitation amounts from 655.87 mm to 3140.88 mm.

3.1. Long-term trend of SOI time series

Sustained negative values of the SOI often present El Niño episodes and usually accompanied by continuous warming of the central and eastern tropical Pacific Ocean, and a decrease in the strength of the

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Corresponding address: Department of Civil & Environmental Engineering, Yamanashi University, Kofu 400-8511, Japan. Tel: (055)220-8603; Fax: (055)253-4915

Pacific Trade Winds. Positive values of the SOI present La Niña episode and are associated with stronger Pacific Trade Winds and warmer sea temperatures (Mosley, 2000). In order to verify the possible long-term trend of the SOI time series, the Mann-Kendall test is performed for the annual SOI record. The hypothesis H_0 is accepted at the level 5% of significance with Z_c=-1.044. The Mann-Kendall slope is –0.031. In other words, it is unable to get the conclusion that the SOI has decreasing trend during the past century, but it seemed tending to decrease with the rate of 0.31 per decade or tended to have more El Niño episodes than La Niña episodes during the past century.

3.2. Cross-correlation between SOI and precipitation time series

The Kendall test is also efficient for correlation analysis. Related results are presented in Table 1. It is shown that most of the rivers (86%), where the hypothesis H_0 is rejected, appeared in Asia and the Pacific Monsoon zone such as Australia, Indonesia, and Thailand. It seems clear that no significant correlation has been found at the northern zone in China, Japan, and Korea, although the Taizi River in China rejected the hypothesis H_0 at the 5% level of significance. If the linear association can be verified, the parametric test usually has greater power than its nonparametric counterpart. The Pearson correlation coefficient r is, therefore, also estimated in this study. Results are given in Table 1 as well. Obviously, the parametric test gives the same result with the nonparametric test.

Table 1. Test results for the correlation between SOI and precipitation

Country	No.	River	r_c	τ_a/τ_b	R/A
Australia	1	Burdekin River	0.386	0.166	R
	2	Pioneer River	0.326	0.225	R
	3	Scott Creek	0.358	0.353	R
China	4	Taizi-He	0.379	0.295	R
Indonesia	5	Bengawan Solo	0.342	0.218	R
	6	Kali Brantas	0.530	0.338	R
Thailand	7	Mae Nam Ping	0.351	0.264	R

In conclusion, the precipitation from most of the river basins in the study area presented positive correlation with the SOI time series. In other words, La Niña may accompany more precipitation and El Niño may accompany less precipitation at most of the river basins in Southeast Asia and the Pacific region. Previous studies, such as those by Chiew et al. (1998) and McKerchar et al. (1998), have shown that the El Niño events are associated with an increased possibility of drier weather in Australia. Those investigations provide positive evidences for the conclusion obtained in this study.

4. Conclusions

The study in this paper has shown that the Southern Oscillation Index (SOI) time series did not presented significant trend, but seemed having decreasing tendency during the past century. In the 30 time series of precipitation, 7 records (23%) have shown significant correlation with the SOI time series at the 5% level of significance, and most of those rivers are located in the Australia-Indonesia region. It also showed that La Niña may accompany more precipitation and El Niño may accompany less precipitation at most of the river basins in Southeast Asia and the Pacific region. But it may be opposite for the northern zone of the region including China, Japan, and Korea.

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