CROSS-CORRELATION BETWEEN SOUTHERN OSCILLATION INDEX AND MONTHLY PRECIPITATION IN PUSAN, KOREA

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1. Introduction

The El Niño/Southern Oscillation (ENSO) results from the interactions between large-scale oceanographic and atmospheric circulation processes in the equatorial Pacific Ocean. There has recently been considerable interest in the El Niño/La Niña, which are known as extremes of Southern Oscillation. The oscillation can be measured by a simple index, the Southern Oscillation Index (SOI) which is used by NOAA (National Oceanic and Atmospheric Administration) to judge whether the El Niño and La Niña events occurring[1).

However despite the global impact of the Southern Oscillation, there has been little evidence of El Niño/La Niña influence in middle to high latitude. Although we have been studying the relationship between SOI and precipitation so far, the significant direct correlation coefficient was not found using original time series. However, we succeeded to detect the cross-correlation by the simple method using categorized SOI in Fukuoka, Japan, for the first time[2). Therefore, in this study, method of categorization of SOI was also applied to this study and revealed the cross-correlation between categorized SOI and precipitation in Pusan, Korea.

Consequently, possible influences of El Niño and La Niña are assessed and presented in respect of the precipitation distribution pattern in the study area.

2. Rainfall Station and Used Data

The Pusan station (129° E, 35.1° N) is located in the southeastern part in Korea as shown in **Fig. 1** and has a record of precipitation since April, 1904, which is one of the longest precipitation record in Korea and it is very close to Fukuoka.

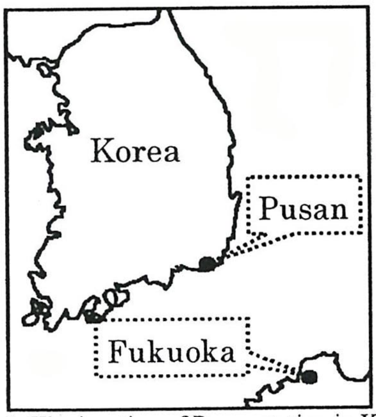

Fig. 1. The location of Pusan station in Korea

In Korea, the modern observation was started in 1904. At that time, the Chosen Governor-general Division established the four stations for modern observation of precipitation. Pusan station is one of the four stations, which include Mokpo, Inchon and Wonsan station. (Wonsan station is located in North Korea)

Even though there are missing values in Inchon station during the Korean War between 1950 and 1952, there is no missing value in Pusan station. Therefore, the precipitation data of period between April 1904 and December 2000 were available for this study.

Box-whisker plot was used to show the statistical summary of Pusan station where values of median, quartiles, maximum and minimum precipitations were presented in **Fig. 2**. The maximum monthly median precipitation was revealed in July, although the maximum monthly precipitation was occurred in June. Remarkably, there is no precipitation as a minimum value between December and March during the winter season in Pusan.

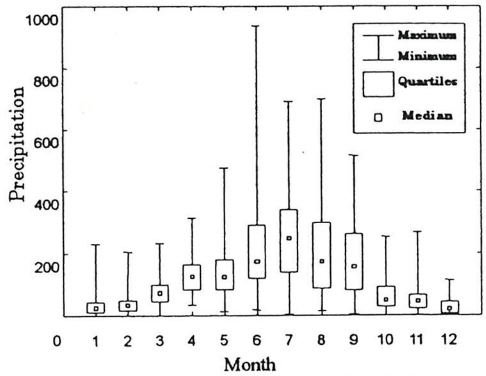

Fig. 2. Box-whisker plot of precipitation in Pusan station

The precipitation data for each month (January-December) in Pusan are not normally distributed but positively skewed. Therefore, cubic root transformation was carried out to normalize the precipitation data. The normalized monthly precipitation values were standardized to a mean of zero and a standard deviation of one by subtracting the normalized monthly mean values from the monthly values and dividing by normalized monthly standard deviations, using whole data period for computation of means and standard deviations[2).

The Troup's method (Troup, 1965) was used to calculating SOI[3). First, the difference between mean sea level pressure at Tahiti (149.6° W, 17.5° S) and Darwin (130.9° E, 12.4° S) and then the differences are standardized to a mean of zero and a standard deviation of one by subtracting the mean value from the differences and dividing by the standard deviation of each month (January-December), using the base period of 1951-1980 for the computation of means and standard deviations.

3. Categorization of SOI

As mentioned above, the concrete influence of El Niño/La Niña is not so clear, especially in middle to the high latitudes, including Korea. When the original time series was used to calculate, no cross-correlation was detected for any lag time that was the same result with the cross-correlation for the original time series of precipitation in Fukuoka. Therefore, as the next step the categorized SOI was tried to this study to calculate correlation coefficient with precipitation in Pusan. The SOI data are categorized into five groups according to their magnitudes; "Strong El Niño (SOI<-2)","Weak El Niño (-2≤SOI<1)" and "Normal Condition(-1≤SOI<1)" and "Weak La Niña (1<SOI≤2)", "Strong La Niña (2<SOI)". This naming for each categories of SOI is for easy association with the El Niño and La Niña phenomena.

4. Cross-Correlation between Categorized SOI and Precipitation in Pusan

The normally standardized precipitation was used to investigate the relationship with categorized SOI. The result is shown in **Fig. 3**. The cross-correlations between categorized SOI and corresponding precipitation were calculated with various lag times.

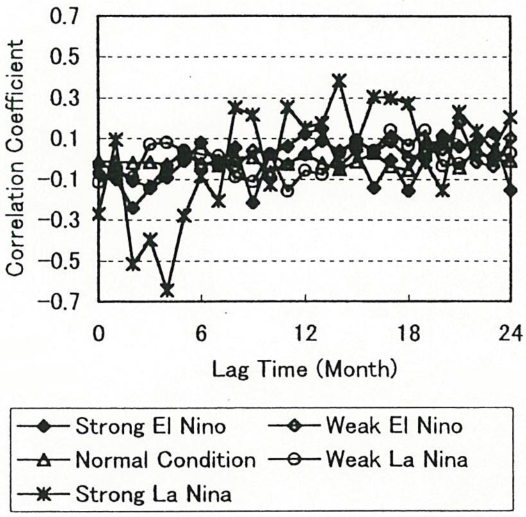

Fig. 3. Cross-correlation between categorized SOI and corresponding normally standardized precipitation in Pusan station

Generally, the correlations under the "Normal Condition" are almost zero at any lag time and La Niña events are more strongly correlated to the precipitation data than El Niño events. The correlations under "Weak El Niño" and "Weak La Niña" are bigger than normal condition but not statistically significant. The highest correlation of −0.65, which is significant at 1% level, is obtained with lag time 4 months and the correlation of −0.52, which is significant at 5% level, is obtained with lag time 2 months under the category of "Strong La Niña". The highest correlation of −0.24 with lag time of 2 months is obtained under the category of the "Strong El Niño" but the correlation is not statistically significant.

We now focus on the data which are detected as statistically significant by the cross-correlation analysis carried out in this study, to investigate in more detail the influence of La Niña on precipitation in Pusan. The scatter plot between SOI categorized as "Strong La Niña" and the corresponding precipitation with lag time 4 months is shown in **Fig. 4**. From this figure, we can see the tendency in which the stronger the La Niña event, the less the precipitation at Pusan 4 months later.

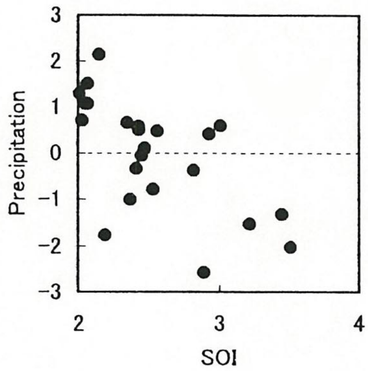

Fig. 4. Scatter plot for the "Strong La Niña" with lag time 4 months

5. Conclusions

In this study, the precipitation data of Pusan station that is one of the longest data records in Korea was used for investigating the cross-correlation with categorized SOI. The descriptive statistics were briefly presented. The relationship with SOI data was evaluated with the primary objective of assessing the possible influence of the Southern Oscillation on precipitation in Pusan, Korea.

The result shows a general tendency in which the stronger La Niña event, the less precipitation, 4 months later and the same general tendency is also shown in lag time 2 months that is significant at 5% level. The result of the cross-correlation under the category of "Strong El Niño" is not statistically significant.

However, the further studies are recommended for evaluations of the possible factors that might be responsible for the observed varied trends.

References

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