Nonlinear Canonical Correlation Analysis of the Korea Precipitaiton with Sea Surface Temperature near East Asia

김광섭*, 순밍동**
Kim, Gwangseob, Sun Mingdong,

Abstract

The NLCCA has been applied to analyze the East Asia sea surface temperature (SST) and Korea monthly precipitation, where the eight leading PCs of the SST and the eight PCs of the precipitation during 1973-2007 were inputs to an NLCCA model. The first NLCCA mode is plotted in the PC spaces of the Korea precipitation and the world SST present a curve linking the nonlinear relationship between the first three leading PCs of Korea precipitation and world SST forthright. The correlation coefficient between canonical variate time series u and v is 0.8538 for the first NLCCA mode. And there are some areas' climate variability have higher relationship with Korea precipitation, especially focus on the north of East Sea' climate variability have represented the higher canonical correlation with Korea precipitation, with the correlation coefficient is 0.871 and 0.838. Likewise in Korea, most stations display similarly uniform distributing characteristic and less difference, in particular the inshore stations have display identical distributing characteristic. In correlation variables' scores, the fluctuation and variation trend are also seasonal oscillation with high frequency.

Key Word : NLCCA, Korea Precipitation, SST, East Asia

1. Introduction

Among the different aspects of climate changes, precipitation is the major source of water for agriculture, industry and municipal water use, which are most important for hydrological cycle in East Asia. Itis a growing concern in the scientific community over the significant increase in precipitation amount and intensity.

There has been much research about analysis of precipitation, and a number of studies on the inter-annual precipitation of different regions have emphasized the different trends depending on the region of interest and time periods employed in each individual study (Robinson 2006,Peel 2008, Becker et al 2006, Jin et al 2005).

In this research, some the nonlinearstatistic analysis method was applied to the Korea precipitation, sea surface temperature over East Asia and focusing on a regional impact on climate change and the interactions correlation relationship between the Korea precipitation and sea surface temperature in East Asia.

2. Methodologies and Data Description

2.1 Methodology

* 정회원・경북대학교 건축・토목공학부 토목공학전공 교수・E-mail : kimgs@knu.ac.kr

** 경북대학교 건축・토목공학부 토목공학전공 박사과정・E-mail : mingdongsun@hotmail.com

In NLCCA, the nonlinear analog of linear CCA, the linear mappings in equationare replaced with nonlinear mappings performed by neural networks. Weight and bias parameters in these two networks are also found by minimizing the cost functions. Once the first mode has been extracted from the data, the next leading mode can be extracted from the model residuals, and so on for higher modes. For canonical variates normalized to unit variance and zero mean, the linear least-squares regression solution is given by $\hat{v} = u \cdot cor(u,v)$ (Hsieh 2000).

2.2. Data description

There are two parts data in this research, Korea precipitation and sea surface temperature, which respectively came from Korea Water Management Information System Data Set and International Comprehensive Ocean-Atmosphere Data Set (ICOADS).

These SST data come from ICOADS, the website is http://icoads.noaa.gov/, and The International Comprehensive Ocean-Atmosphere Data Set (ICOADS) is the most extensive collection of surface marine data available for the world ocean over the past two centuries. Spatial coverage is global grid 2.0 degree latitude×2.0 degree longitude.

Therefore, 61 stations in Korea and grid 0°N-60°N, 75°E-150°E over Ease Asia which have 413 months(1973.1-2007.5) records of monthly data are used for the current study, and trends in precipitation amount, intensity and heavy rainfall are investigated.The available data maintained with extensive quality control and calculation of monthly data, which are the most important processes for studying the frequency and intensity.

3. Application

The nonlinear canonical correlations analysis (NLCCA)has been applied to analyze the sea surface temperature (SST) with Korea monthly precipitation data. These works aim for to investigate the nonlinear relations associated with the evolution between the precipitation and SST. For present the evident and better research work, the data were prefiltered by linear principal component analysis, with only the first eight leading modes were retained and inputed to an NLCCA model.

The first eight leading PCs of the precipitation and the first eight leading PCs of SST during 1973-2007/5 were inputs to an NLCCA model, which account for 93.56% and 70.63% of the total variance respectively.

The first mode canonical variate time series u and v are plotted as a function of time from 1973 to 2007 in figure 1. The correlation between u and v is 0.7947 for the NLCCA. The figure showing that the canonical variates u of Korea precipitation is noisier than the canonical variates v of SST.

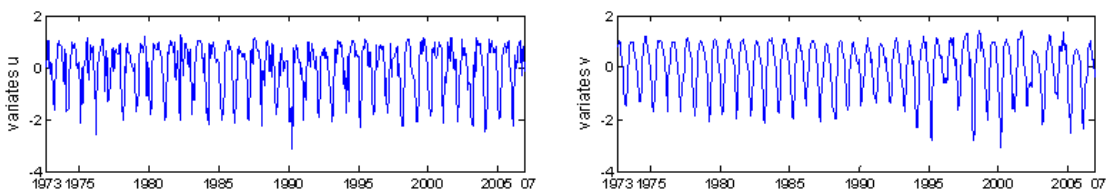

Fig. 1 The canonical variable u and v plotted in NLCCA 1st mode

For a given value of u, one can map from u to the eight PCsof Korea precipitation. Each of the PCs can be multiplied by its associated PCA spatial eigenvector pattern, and the eight modes added together

to yield the spatial anomaly pattern for that particular value of u. For the first NLCCA mode, as u varies from its minimum value, half minimum to half its maximum, maximum value, the Korea precipitation field varies from the rainy season phase to the drought season. The Korea precipitation spatial distribution of maximum u and minimum u are show in figure 2.

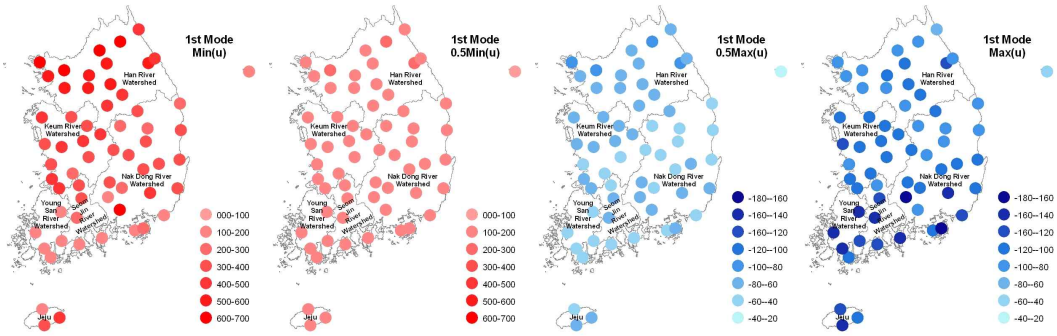

Fig. 2 Korea precipitation spatial field as min(u), 0.5min(u), 0.5max(u) and max (u) in 1st mode

Similarly, as v varies from its minimum to its maximum, the SST field varies from strong La Nina to strong El Nino phase.The SST filed when the canonical variates v of the NLCCA 1st mode from its maximum, half its maximum to and its half minimum and minimum are show in figure 3.

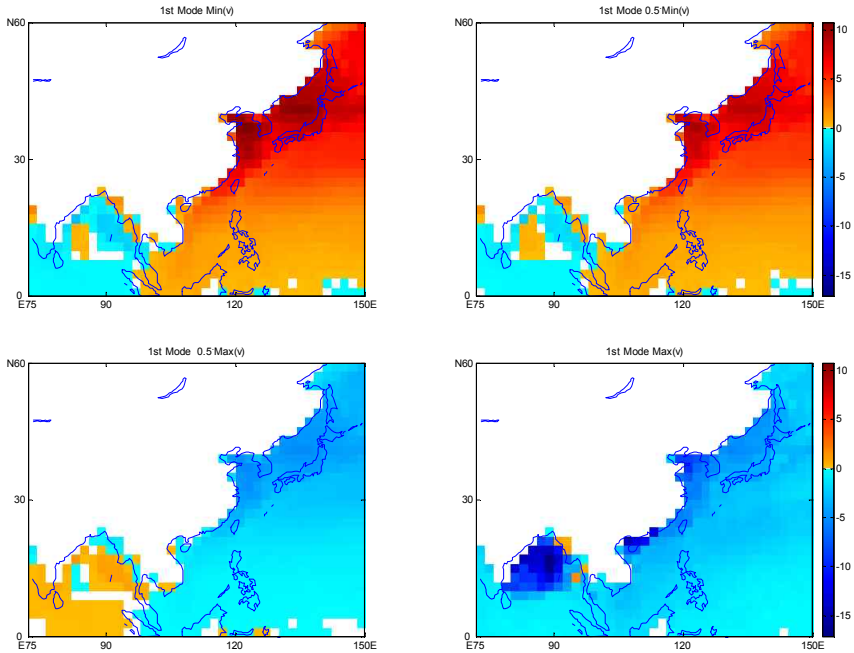

Fig. 3 East Asia SST filed as min(v), 0.5min(v), 0.5max(v) and max (v) in 1st mode

After the first NLCCA mode had been extracted, the residual, the original data minus the first NLCCA mode, was served as input to the NLCCA network with eight pairs of input PCs again to extract the second NLCCA mode. The canonical variates for NLCCA second mode are plotted as a function of time in figure 4, showing that second mode is noisier than first mode, but it also has longer timescale oscillations.

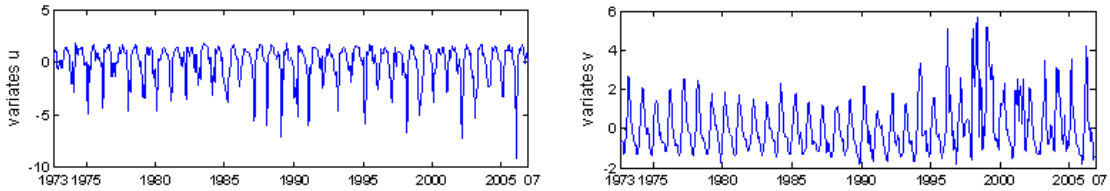

Fig. 4 The canonical variable u and v plotted in NLCCA 2nd mode

The spatial patterns of the Korea precipitation and East Asia SST associated with the NLCCA 2nd mode are shown in figure 5and figure 6.

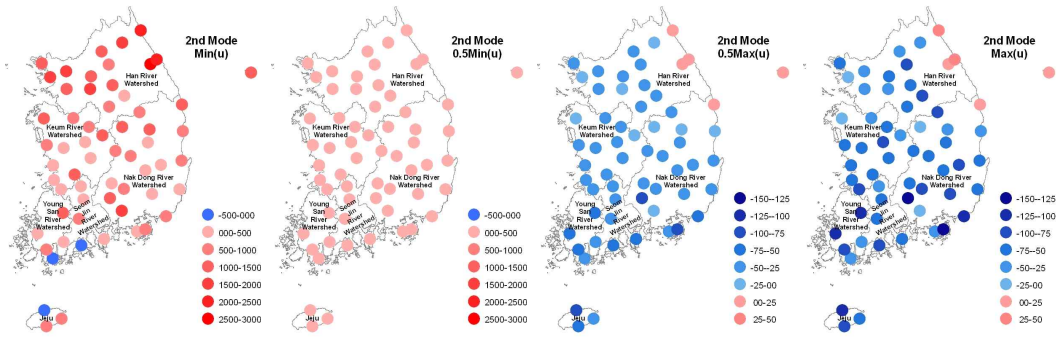

Fig. 5 Korea precipitation spatial field as min(u), 0.5min(u), 0.5max(u) and max (u) in 2nd mode

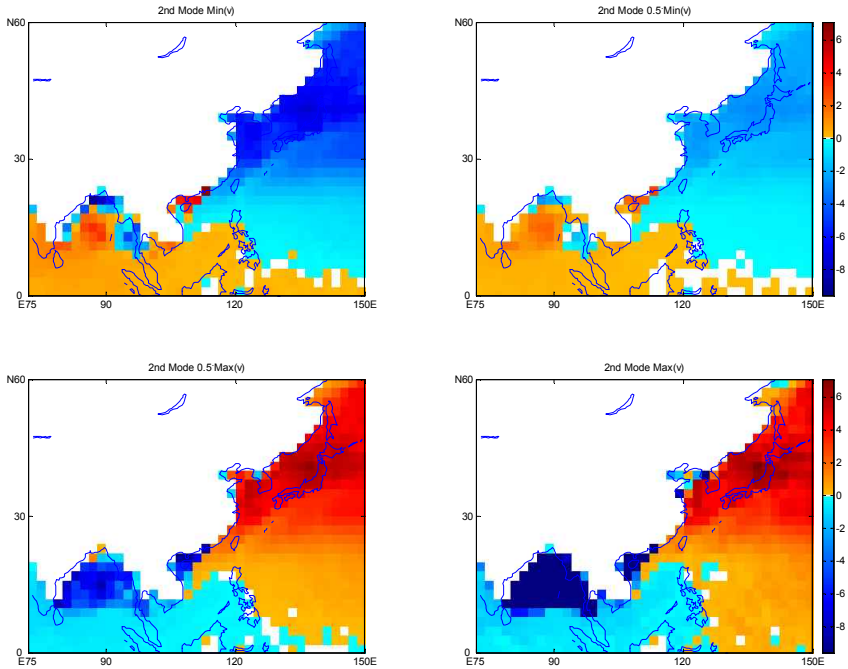

Fig. 6 East Asia SST filed as min(v), 0.5min(v), 0.5max(v) and max (v) in 2nd mode

In above two model description, there are some areas have higher relationship with Korean precipitation in East Asia sea surface temperature, which is area of the East Sea. In Korea, Han River watershed mostly exhibit positive correlation, and others have uniform distributing characteristic. About correlation variables' scores, we can find both are similar in fluctuation and variation trend, they accord with precipitation seasonal variation.

4. Conclusion

We have applied the nonlinear canonical correlation analysis technique to the monthly precipitation data of 61 stations during 36 years in Korea with between sea surface temperatures. These works aim for to investigate the nonlinear relations associated with the evolution of the precipitation and climate index, the eight leading PCs modes of Korea precipitation account for 93.56% of the total monthly variance, the eight leading PCs modes of the SST account for 70.63% of the total monthly variance respectively. There are some areas' climate variability have higher relationship with Korea precipitation, especially the area of East Sea's. Likewise in Korea, most stations display similarly uniform distributing characteristic and less difference, in particular the inshore stations have display identical distributing characteristic. In correlation variables'scores, the fluctuation and variation trend are also seasonal oscillation with high frequency.

In summary, the nonlinear relationship between Korea precipitation and East Asia SST are represented by using NLCCA method, it generally describe another view about the region impact research work.

감사의 글

본 연구는 21세기 프론티어 연구개발사업의 수자원의 지속적 확보개발사업단의 연구비 지원(1-9-3)에 의해 수행되었습니다.

참고문헌

1. Robinson,P.J.(2006). Implications of long-term precipitation amount changes for water sustainability in North Carolina,*Physical Geography*, Vol. 27, No. 4, pp.286-296.
2. Peel, S., Wilson, L.J. (2008). A Diagnostic Verification of the Precipitation Forecasts Produced by the Canadian Ensemble Prediction System, *Weather and Forecasting*, Vol. 23, No. 4, pp. 596-616.
3. Becker,S, Gemmer,M,and Jiang,T.(2006). Spatiotemporal analysis of precipitation trends in the Yangtze River catchment, *Stochastic Environmental Research and Risk Assessment*, Vol. 20, No. 6, pp. 435-444.
4. Jin,Y.H., Kawamura,A., Jinno,K., andBerndtsson,R.(2005). Detection of ENSO-influence on the monthly precipitation in South Korea, *Hydrological Process*.Vol. 19, No. 20,pp. 4081-4092.
5. Hsieh, W.W. (2000). Nonlinear canonical correlation analysis by neural networks, *Neural Networks*, Vol. 13, pp. 1095-1105.