Relationship between land cover and monsoon interannual variations in east Asia

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Abstract: Asian monsoon have multiple forms of variations such as seasonal variation, intra-seasonal variation, interannual variation, etc. The interannual variations have not only yearly variations but also variations among several years. In general, the yearly variations are described with winter temperature and summer precipitation, and the variations among several years are reflected by circulation of ENSO events. In this study, at first, we analyze the relationship between land cover and interannual monsoon variations represented by precipitation changes using Singular Value Decomposition method based on the time series precipitation data and 8km NOAA AVHRR NDVI data covering 1982 to 1993 in east Asia. Furthermore, after confirmation and reclassification of ENSO events which are recognized as the strong signal of several year monsoon variation, using the same time series NDVI data during 1982 to 1993 in east Asia, we make a Principle Component Analysis and analyzed the correlation of the 7th component eigenvectors and Southern Oscillation Index (SOI) that indicates the characteristic of ENSO events, and summed up the temporal-spatial distribution features of east Asian land cover’s inter-annual variations that are being driven by changes of ENSO events.

Key words: east Asian land cover; monsoon climate; interannual variations; Singular Value Decomposition; ENSO events; Principle Component Analysis

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1 Introduction

In recent years, with the degeneration of environment, close attention has been paid to the mechanism of land cover changes (Li, 1996), for which the global climate change plays a very important role, and the vegetation variances can represent the climate change to some extent (Chen et al., 1996; Li, 1996; Wu, 1996). Because vegetation is the natural “tie” linking the elements of soil, atmosphere and water, etc., and the dynamic change of vegetation can represent the dynamic change of land cover to a certain extent (Chen et al., 1998). It is known that the vegetation dynamic monitoring began with remote sensing, and the vegetation indexes calculated from remote sensing data are indirect indicators of vegetation growth, cover, biomass and species, etc. There are many kinds of vegetation indexes according to the remote sensing platforms and sensors. Among them the Normalized Difference Vegetation Index (NDVI) is found to provide a strong vegetation signal. Therefore, in recent years, considerable attention has been focused on the NDVI products that can be produced from the AVHRR sensor of the NOAA series satellites (Justice, 1985). For example, acting as an important remote sensing parameter of vegetation, NDVI has been used extensively in the fields of global change and land use/land cover change (Eric et al. 1997; Gong et al., 1996; Tucker et al., 1985).

Asian monsoon climate has multiple forms of variations such as seasonal variation, intra-seasonal
variation and interannual variation, and the interannual variations have both yearly variations and variations among several years. In general, the yearly variations are described with winter temperature and summer precipitation, and the variations among several years are reflected by circulation of ENSO events. Because ENSO events are not only the strong signal of monsoon climate's several years changes, but also the important driving force of land cover dynamic changes. ENSO events have influence of global scale, and the abnormalities of climate elements such as precipitation and temperature of many places are closely related to the ENSO events (Wang et al., 1999a). ENSO events directly influence the vegetation and indirectly influence the land cover dynamics through effecting the key elements of climate such as temperature and precipitation (Kogan, 1998). So far studies of the relationship between land cover and monsoon climate changes in east Asia represented by precipitation variance and ENSO circulation are not available, this kind of research is of great importance to the global change study. In this study, we try to investigate the relationship of land cover and interannual climate change in east Asia using time series 8 km NOAA AVHRR NDVI images, precipitation data and Southern Oscillation Index data.

2 Data source and its processing

2.1 Precipitation data and its processing

The basic data sets used in this research are taken from “global long time series weather station’s report data sets for monthly precipitation and monthly mean temperature” complied by Institute of Atmospheric Physics, Chinese Academy of Sciences. At first, by means of data-base management software, we selected the precipitation data from global data sets covering 1982 to 1993 within the spatial scope of 60°E-150°E longitude and 65°N-18°N latitude. Then we used GIS technology to generate the weather stations cover in light of their longitude and latitude, and jointed the precipitation data and attribute data of weather station cover in terms of the weather station sequences. We also used the Inverse Distance Weighted (IDW) interpolation method to interpolate the monthly precipitation data from 1982 to 1993 into grid imageries and calculated the monthly average precipitation in May-September of each year during 1982-1993. In the process of data treatment, the following points are taken into account: 1) east Asian vegetation in summer (May-September) is sensitive to the monsoon climate characterized by synchronous existence of rainy season and thermal climate; and 2) the annual average precipitation during May-September can partially eliminate the seasonal variance of precipitation, so it can soundly reflect the interannual changes of monsoon climate.

2.2 NDVI data and its processing

The NDVI data used in this study is provided by the USGS EROS data center for the years 1981-1994. This data set has an 8-km spatial resolution and a 10-day temporal resolution with a spatial scope of 25.6°E-143.7°E and 4.5°S-79°N. In order to match the precipitation data, only the data covering 1982 to 1993 have been used. In addition, supported by GIS technology, the monthly May-September averaged NDVI imageries of each year have been calculated. May-September of each year is regarded as the main factors to be considered: 1) the east Asian summer seasonal vegetation is highly sensitive to the monsoon climate characterized by synchronous existence of rainy season and thermal climate; and 2) monthly average NDVI during May-September can partially eliminate the seasonal changes of vegetation, thus it can fully reflect the interannual variance of vegetation.

2.3 Southern Oscillation Index

ENSO is the abbreviation of El Nino and Southern Oscillation. El Nino usually indicates the phenomena of large-scale temperature anomaly increase in the eastern part of the equatorial Pacific Ocean. Southern Oscillation means the air pressure oscillation between the Indian Ocean and southeast tropical Pacific Ocean. In order to show the intensity of Southern Oscillation, many researchers have designed various kinds of indexes, among them a commonly used index named Southern Oscillation Index (SOI), which is the slippage averaged difference of sea level atmospheric pressure between Tahiti Island and Darwin harbor. Before the 1960s, El Nino and Southern Oscillation were studied separately. With the increase of observing materials and in-depth research, people have gradually found out the relationship of these two phenomena since the 1960s. Because the relationship of El Nino and Southern Oscillation has been