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Investigation of Vegetation Dynamics of Mongolia Using Time Series of NDVI in Response to Temperature and Precipitation

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Abstract

Climate is one of the most important factors affecting the condition of vegetation. Plants are highly sensitive to climate change and display the most sensitive response to the effect of the climate change and environment, most particularly seen in the annual and seasonal alternations of vegetation productivity. Through the analysis of remotely sensed images, it is proved that vegetation indices can give significant information regarding vegetation. The main purpose of this study was to estimate the influences of precipitation and temperature on spatio-temporal pattern of vegetation dynamics in Mongolia using MODIS sensor derived NDVI images over the course of 10 years. The correlation coefficient showed that mean growing season NDVI was correlated with both climatic factors, but more significantly correlated with precipitation (r^2=0.92, p=0.000) than temperature (r^2=0.55, p=0.013). Growing season precipitation slightly decreased with an annual average decrement of 0.2 mm (r^2=0.06). Meanwhile, the growing season mean temperature slightly increased over 10 years, with an annual average increment of 0.01°C per year (r^2=0.003) from 2000 to 2009. However, the relationship between NDVI and climatic factors, and their change trends have been varied spatially and temporally.

Key words: Normalized Difference Vegetation Index, precipitation, temperature, correlation analysis, Mongolia

Introduction

Climatic condition is one of the most important factors affecting the structure and dynamics of vegetation. Plants are highly sensitive to climate change and display the most sensitive response to the effect of the climate change and environment, which particularly seen in the annual and seasonal alternations of vegetation productivity (Wang *et al*., 1999). Through the analysis of remotely sensed images, it is proved that vegetation indexes can give the more significant information regarding vegetation. The Normalized Difference Vegetation Index (NDVI) is a widely used one among vegetation indices, and it is the perfect indicator of coverage, growth, biomass as well as photosynthesis of the vegetation (Keeling *et al*., 1996; Piao *et al*., 2003). NDVI is defined by following formula:

$$NDVI = \frac{P_{nir} - P_{red}}{P_{nir} + P_{red}} \quad (1)$$

where, P_{nir} refers to reflection rate of the near infrared waveband and P_{red} refers to the reflection rate of red waveband.

Although the correction to remove the effects of atmosphere has already been carried out on NDVI images (Vermote & Vermeulen, 1999), but some noise was still observed in the datasets due to minor cloud cover, water, snow or shadow. In order to eliminate further these noises, the Maximum Value Composite was used in data preprocessing. Regression or correlation technique is the common empirical approaches used to quantify the relationships between two and more variables (Zimmerman, 1986). For the two variables, x and y, the correlation coefficients calculated as:

$$r_{xy} = \frac{\sum_{i=1}^{n} \overline{x_i - (y)}}{\sqrt{\sum_{i=1}^{n} (x_i - \bar{x})^2} \times \sqrt{\sum_{i=1}^{n} (y_i - \bar{y})^2}} \quad (2)$$

where, n is the number of samples; x_i represents the value of x for the sample i; y_i