A NEW METHOD FOR DETECTION GREENING OR BROWING CHANGE TREND IN VEGETATION FROM NDVI SEQUENCES

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Abstract

NDVI trends can approximate the trend of greening or browning of vegetation, and reflect the adaptation process of vegetation to global change.

In this paper, a NDVI trend analysis method combining EMD (Empirical Mode Decomposition) and MK (Mann-Kendall) significance test is proposed on vegetation monotone trend detection. The method includes mainly two steps: firstly, EMD is used to decompose NDVI time series into a finite number of intrinsic mode functions (IMF), these components contain the local characteristic information of different time scales of the original signal. Secondly, we use the MK significance test to detect the monotonicity of the trend varied, that is to detect the trend is monotonically increasing or monotonically decreasing, the monotonically increasing is corresponding to the trend of vegetation getting greening, the monotonically decreasing is corresponding to the trend of vegetation getting browning.

Introduction

Vegetation status is often used to assess the productivity and degradation of natural and agricultural land. Trends in vegetation change are considered to be associated with land degradation.

Within the framework of decades, it is generally believed that sudden vegetation loss may be caused by short-term processes such as fires, harvesting or disasters, and sudden greening of vegetation may also be caused by rainfall events or reduction of snow cover. Vegetation gradual change will occur over a longer period of time, reflecting the adaptation process of vegetation to global change.

Based on the NDVI data of local areas in China from 2006 to 2015, the empirical mode decomposition (EMD) combined with Mann-Kendall saliency test was used to analyze the monotonic change of vegetation. The experimental results also show that this method is an effective method for time series change trend analysis.

Methods and Materials

1.EMD

EMD is a new time-frequency signal analysis method proposed by Huang et al. in 1998. This method belongs to the adaptive local time-frequency analysis method. It can be decomposed into a finite number of IMFs according to the characteristics of the data signal itself. The decomposed IMF components contain local characteristic signals of different time scales of the original signal. It is especially suitable for the analysis of non-stationary signals.

$$x(t)=\sum^{n} imf_i(t)+r_n(t)$$

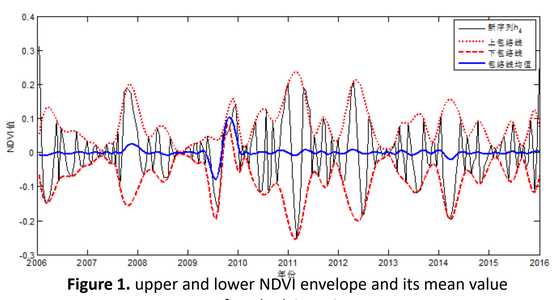

Figure 1. upper and lower NDVI envelope and its mean value after the k iteration.

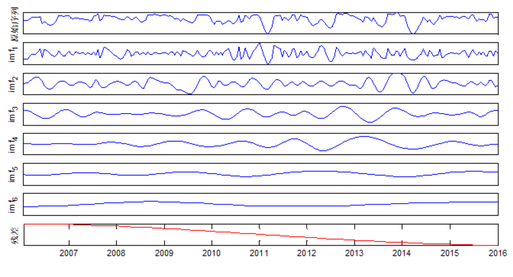

Figure 2. decomposition results by EMD method.

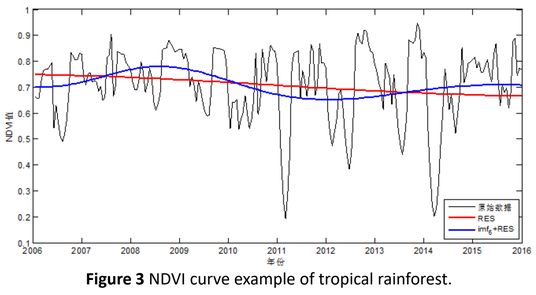

Figure 3 NDVI curve example of tropical rainforest.

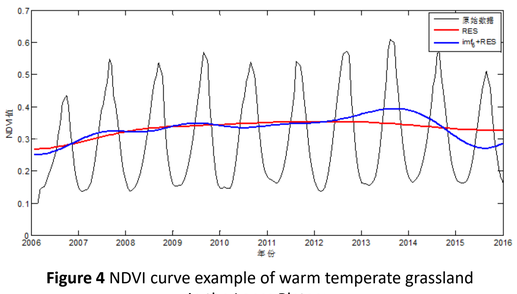

Figure 4 NDVI curve example of warm temperate grassland in the Loess Plateau

2. **Mann-Kendall test method**

Mann-Kendall test, originally proposed by Mann and Kendall, is used to detect the long-term trend and abrupt change of precipitation in waters. It is suitable for non-normal distribution data.

Test statistics S formula:

$$S=\sum_{i=1}^{n-1}\sum_{j=i+1}^{n}\operatorname{sgn}(x_j-x_i) \qquad \operatorname{sgn}(\theta)=\begin{cases}1 & \theta>0\\ 0 & \theta=0\\ -1 & \theta<0\end{cases}$$

When *n > 10*, it approximates the normal distribution, its mean value is 0, variance *var (S) = n (n-1) (2n + 5) / 18*. The standard normal system variable Z_{MK} is calculated by formula:

$$Z_{MK}=\begin{cases}(S-1)/\sqrt{\operatorname{var}(S)} & S>0\\ 0 & S=0\\ (S+1)/\sqrt{\operatorname{var}(S)} & S<0\end{cases}$$

For statistics Z_{MK}, $Z_{MK}>0$ is an upward trend; $Z_{MK}<0$ is a downward trend. When the significance level is α, the confidence is (1- α) 100%. In this study, we require 95% confidence, then Z_{MK} = 1.96.

Results

The satellite image of each sample area is extracted by trend, and the NDVI median and NDVI trend are as follows:

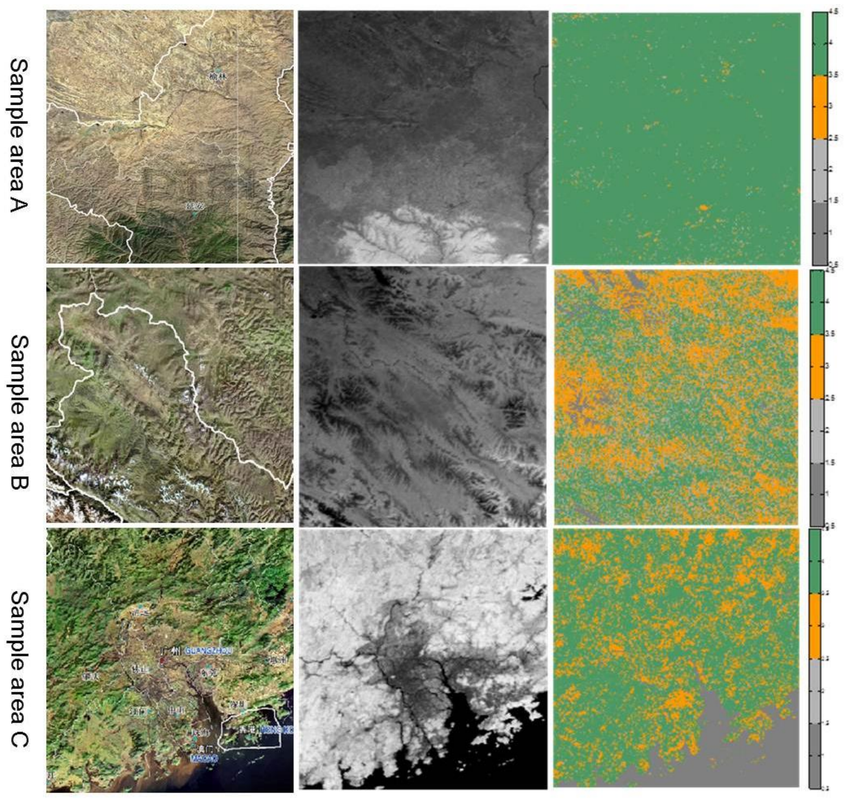

Figure 2. The satellite images, NDVI median images, NDVI trend images, and color bars of three sample areas from left to right.

Dark gray indicates no significant change in vegetation in the past ten years, light gray indicates that NDVI value is less than 0.1, that is, there is little vegetation, orange indicates that the vegetation has a tendency to brown in the past ten years, and green indicates that the vegetation has a tendency to turn green in the past ten years.

Discussion

From the distribution of NDVI, the vegetation in the sample area A shows a green trend in general from south to north. This phenomenon is consistent with the improvement of ecological environment.

The distribution of B in the sample area is relatively complex from satellite images and NDVI trend maps.

In the sample area C, from the trend of vegetation change, there are also browning areas and greening areas. The browning area is mostly associated with urban expansion and economic development.

Conclusions

This paper presents a new method to detect the trend of vegetation greening or browning from NDVI sequence by EMD combined with Mann-Kendall test.

The trend of vegetation change in North, West and South China in the past ten years from 2006 to 2015 is analyzed. The results show that the proposed method is an effective time series trend analysis method, which has a certain reference value for the study of long-term ecological change.

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