MONITORING CHANGESES IN 12 YEARS INNER MONGOLIAN GRASSLAND, CHINA, USING SPOT VEGETATION IMAGES

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ABSTRACT: Inner Mongolia grassland, China, which is an important grazing area, has been suffered a land degradation due to mainly an overgrazing and unconscionable land use. This study investigated the change detection of 12-year (1999-2010) in Inner Mongolia grassland using Spot VEGETATION (VGT) satellite derived NDVI (Normalized Difference Vegetation Index) imageries. The Spot-VGT data (10-day composite NDVI) in the Inner Mongolia (37–54º N ; 97–127º E) was obtained from ASTRIUM (http://free.vgt.vito.be/). Using time series Spot-VGT NDVI images, seasonal vegetation change and their spatial variation were determined.

1. INTRODUCTION

In Inner Mongolia, China, where the major landscape is grassland, covers 35.87 % of the whole autonomous region area until 1998(Zhong et al, 2005). The Inner Mongolian steppe is a vast grassland ecosystem that has been home to nomadic pastoralists and their herds for thousands of years (Xu et al, 2007). As the most important livestock farming production base in China, grassland ecosystem always plays a really significant role to the human's life and the local environment. However, with the high growth of farming and mining industry, overgrazing, cropland misuse, grassland degradation, even desertification, became a serious problem to the whole region (Akiyama and Kawamura, 2007). In 2002, China central government had made the policy "Grain for green", in order to relieve and solve the vegetation degradation problem that had occurred within the country.

For monitoring the land cover changes of the grassland in Inner Mongolia, remote sensing has long been used as a quite adaptive and convenient tool in the research. Several vegetation indexes were developed and utilized by satellite imagery to monitor the land cover change. Perhaps, normalized difference vegetation index (NDVI) is the most widely used VIs to detect vegetation changes.

The purpose of this study is to find a trend of the land cover changes and spatial distribution from 1998 to 2010, in Inner Mongolia.

2. MATERIALS AND METHODS

2.1 Study area

The study area of Inner Mongolia autonomous located between 97°12′E-126°04′E，37°24′N-53°23′N, which is the third largest province in China (Figure 1). The mean annual precipitation ranges from 35 to 530 mm, and the mean temperature is between − 5 °C and 10 °C (Chen and Wang, 2009).Typical steppes and meadow, which are the major types of the grassland ecosystem, find in Inner Mongolia, and are most commonly used for grazing and animal production (Kang et al., 2007).

Figure 1: Green area shows the spatial position of Inner Mongolia

2.2 Spot-VGT NDVI data

In this study, the NDVI time series data was obtained from ASTRIUM (http://free.vgt.vito.be/), by sensor VGT1 and VGT2, carried on SPOT satellite.

Normalized Difference Vegetation Index (NDVI) has a high correlation at the local scale, with various plant parameters including leaf area index (LAI), biomass, production and percent cover, which has been widely applied to monitor and evaluate terrestrial vegetation vigor at continental or global scales during past couple of decades(F. Huang et al.2008).
It derived from infrared channel and near-infrared channel remote sensing data.

NDVI=(p(nir)-p(red))/(p(nir)+p(red))

Where p(red) and p(nir) represent the surface reflectance in red and near infrared portions respectively(Taehee Hwang et al,2011).
In this study, SPOTVGT vegetation index was used because of its high temporal frequency. SPOTVGT ten days synthesis time series product (S10), with 1-km resolution, was applied here to extract NDVI value (Figure 2).

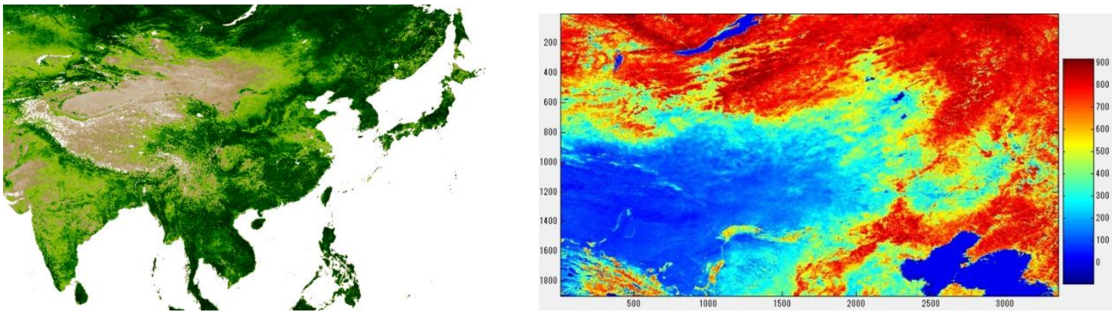

Figure 2: Left one shows the original SPOTVGT NDVI image for the South East Area region (left) and the study area of Inner Mongolia, China (right), in the first ten days July, 2010

2.3 Data processing

By studying the vegetation index time series data, a significant seasonal and annual vegetation changes could be found in the research area. To analyze the NDVI data, TIMESAT (http://www.nateko.lu.se/TIMESAT/timesat.asp) was applied here.

TIMESAT is a software primarily designed to process time-series of vegetation index derived from satellite spectral measurements according to its manual.

Original time series data has quite a lot of noise due to clouds and atmospheric influence. In order to make a mathematic model to fit the data, applying signal filter is quite important to smooth the time series data. TIMESAT

implements three processing methods based on least-squares fits to the upper envelope of the vegetation index data. First one uses polynomial functions in the fitting, and the method can be classified as an adaptive Savitzky-Golay filter. The other two methods are least-squares methods, where data are fitted to non-linear model functions of different complexity. All three processing methods use a preliminary definition of the seasonality along with approximate timing of the growing seasons. TIMESAT software offer several commonly used fitting method, such as Asymmetric Gaussians, double logistic functions, and Savitzky-Golay(Lars Eklundh and Per Jonsson, 2010).
The principle of adaptive Savitzky-Golay method
One way of smoothing data and suppressing disturbances is to use a filter, and replace each data value yi (i = 1, …,N) by a linear combination of nearby values in a window.
The general equation of the simplified least-squares convolution for NDVI time-series smoothing can be given as follows:

$$Yj^* = \sum_{i=-m}^{i=m} (CiYj + i)/N$$

where Y is the original NDVI value, Y* is the resultant NDVI value, Ci is the coefficient for the ith NDVI value of the filter (smoothing window), and N is the number of convoluting integers and is equal to the smoothing window size (2m+ 1). The index j is the running index of the original ordinate data table. The smoothing array (filter size) consists of 2m+ 1 points, where m is the half-width of the smoothing window (Chen et al., 2004). By using Savitzky-Golay method supplied here, vegetation change and spatial distribution were analyzed as a result for this study.
An example showed the Savitzky-Golay fitting method (Figure 3).

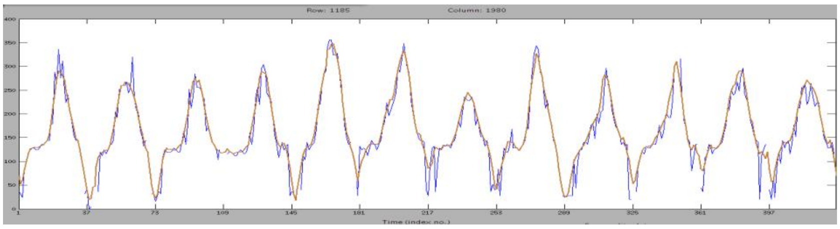

Figure 3: TIMESAT GUI processing window. The horizontal axis represents the time index (interval equals 10 days) , while the vertical axis represents NDVI value. The blue line represents the original data, while the brown line represents the fitted result by Savitzky-Golay method.

Extracting images of seasonal parameters
Seasonal parameters such as the start and end of the season, the amplitude, position of middle of season, maximum of fitted data and so on, had been extracted and conversed into images and statistic tables.

RESULTS

Yearly changes of NDVI time series data was calculated and emerged into image. From 1999 to 2010, the grassland coverage in Inner Mongolia had a big variation. And according to the season length and NDVI value, forest and grassland mainly located in the east and middle part, while arid region mainly located in the west part of Inner Mongolia(Figure 4).

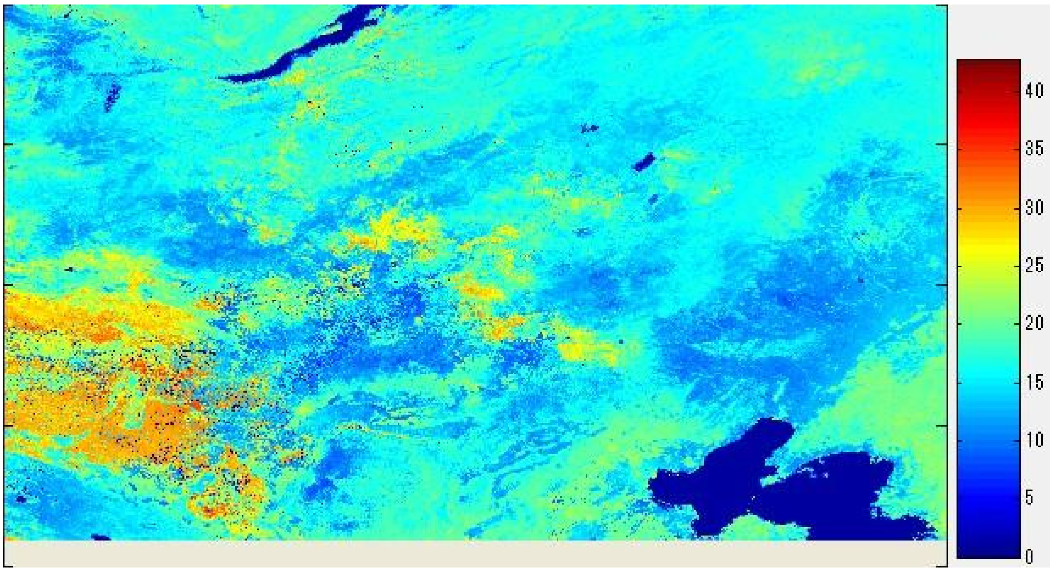

Figure 4: Season length (between start-end) calculated using SPOTVGT NDVI data in 2008

4. DISCUSSION AND CONCLUSIONS

Because of the climate influence and human behavior, the vegetation distribution has an obvious pattern that grassland coverage decreased from east to west. Though china central government has done a good method to recover the vegetation, but the degradation is still a serious problem. In the future, more effort be done in this area. And meanwhile, various monitoring ways should be applied to reply the result of vegetation change in a suitable time interval.

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