NDVI time series analysis over central China and Mongolia

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ABSTRACT: Land cover and its changes, affecting multiple aspects of the environmental system such as energy balance, biogeochemical cycles, hydrological cycles and the climate system, are regarded as critical elements in global change studies. Especially in arid and semiarid regions, the observation of ecosystem that is sensitive to climate change can improve an understanding of the relationships between climate and ecosystem dynamics. The purpose of this research is analyzing the ecosystem surrounding the Gobi desert in North Asia quantitatively as well as qualitatively more concretely. We used Normalized Difference Vegetation Index (NDVI) derived from SPOT-VEGETATION (VGT) sensor during 1999~2007. Ecosystem monitoring of this area is necessary because it is a hot spot in global environment change. This study will allow predicting areas, which are prone to the rapid environmental change. Eight classes were classified and compare with MODerate resolution Imaging Spectrometer (MODIS) global land cover. The time-series analysis was carried out for these 8 classes. Class-1 and -2 have least amplitude variation with low NDVI as barren areas, while other vegetated classes increase in May and decrease in October (maximum value occurs in July and August). Although the several classes have the similar features of NDVI time-series, we detected a slight difference of inter-annual variation among these classes.

1. INTRODUCTION

Land cover and its changes, affecting multiple aspects of the environmental system such as energy balance, biogeochemical cycles, hydrological cycles and the climate system, are regarded as critical elements in global change studies (Nemani et al., 1996 , Xue, 1996). Many researches have been made to study vegetation cover and its changes until now. Huttich et al. (2007) monitored the Northern Eurasia's land-cover change trends using SPOT VEGETION time-series from 1998 to 2005. Christopher et al. (2007) found regions in North America that experienced marked increases in annual photosynthetic capacity. Especially in arid and semiarid regions, the observation of ecosystem that is sensitive to climate change can improve an understanding of the relationships between climate and ecosystem dynamics. Vegetation is one of the earth's most vital natural resources and a mediator in climate and climate change as well. Global warming has caused variation in vegetation phenology and productivity and has inflicted considerable damage. Therefore, there is a pressing need to assess and predict the potential influence of global change on vegetation ecological systems

Differentiation of annual, inter-annual and long-term phenological patterns are an important component of global ecosystems monitoring and modeling (Reed et al., 1994, Schwartz, 1999) and may lead to better understanding of how and why land cover changes over time. Time series of remotely sensed data are an important source of information for understanding land cover dynamics (Bethany et al., 2006). To infer north east Asia vegetation changes we used Normalized Difference Vegetation Index (NDVI) data derived from SPOT VEGETATION during 1999-2007.

The aim of this study is analyzing the ecosystem surrounding the Gobi desert in North Asia quantitatively as well as qualitatively more concretely. Monitoring ecosystem of this area is essential for examining the environment change, because the vegetation in North-Asia is a hot spot in global environment change and this improved study will allow us to predict areas prone to rapid environmental change. Also it is useful for future land use planning purpose.

2. DATA AND METHOD

The study site (Fig. 1) covers an area from 73°37′E to 120°41′E in longitude and from 30°81′N to 52°31′N in latitude (2409×5270km, 12695430 km2). The land cover types vary greatly in this vast area, including evergreen forest, deciduous forest, cropland, shrubland, grassland, and barren deserts like the Gobi Desert. Land cover variability is strongly influenced by the monsoon climate system.

For this research, we use two kinds of main data. The first data is the Normalized Difference Vegetation Index (NDVI) derived from VEGETATION (VGT) sensor onboard the SPOT 4 and 5 satellite and the other one is standard monthly precipitation of the NOAA Climate

Prediction Center (CPC) Merged Analysis of Precipitation (CMAP).

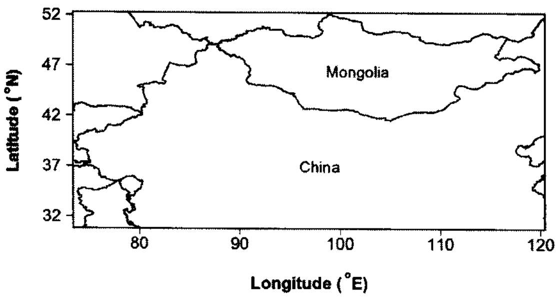

Fig.1 Location of study area

The VGT data set included four spectral bands(blue, red, NIR, MIR) (table 1). Two levels of enhanced products are available to users: P products correspond to data which be mostly used by physicists for methodological development that could be embedded into applications using VEGETATION data and S products where some synthesis is applied on the "Core Archive" data to provide ground reflectance as well as some simply derived parameters. S products are composed by 2 products: The daily synthesis (S1) and the 10-day synthesis (S10). S1 products provide the surface reflectance obtained after pre-processing, such as, geometric and atmospheric corrections. S10 is computed from all the passes on each location acquired during 10-day periods. The periods are defined according to the legal calendar: from 1st to 10th, from 11th to 20th, from 21st to the end of each month. A 10-day synthesis (S10) based on the selection of the "best" measurement of VGT-S1 pixels on the entire period. The selection is based on the Maximum Value Composite (MVC) approach for NDVI, as it is commonly accepted today, even if many problems associated to that selection are identified. This technique helps minimize the effect of variability in atmospheric optical depth and eliminate most cloudy pixels.

Spectral Bands	Wavelength	Surface reflectance range
BLUE	0.46~0.47 ㎛	0.0-0.5
RED	0.61~0.68 ㎛	0.0-0.5
NIR	0.78~0.89 ㎛	0.0-0.7
SWIR	1.58~1.75 ㎛	0.0-0.5

Table 1. Spectral characteristics of SPOT VEGETATION sensor

We used UMd 1km global land cover maps as vegetation classification in 1992 (Fig. 2). The UMd land cover used the data derived from the National Oceanic and Atmospheric Administration (NOAA) AVHRR satellite sensor from April 1992 to March 1993 inclusive.

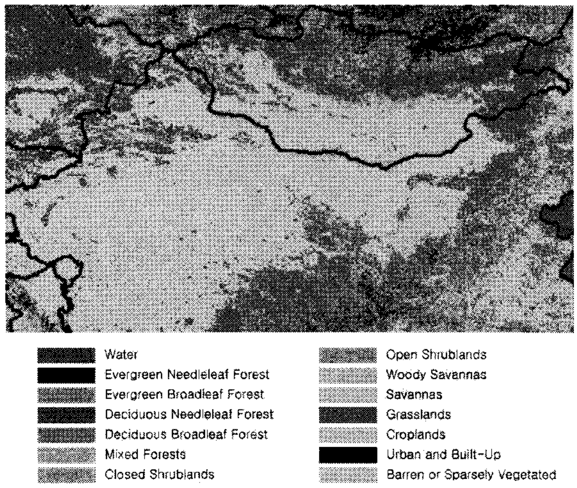

Fig. 2. UMd (University of Maryland) 1km global land cover maps

We use NDVI from SPOT/VGT from 1999 to 2007. Although 10-day composite SPOT NDVI data are generated using the MVC approach which helps minimize the effect of variability in atmospheric optical depth and eliminate most cloudy pixels, data analysis remains affected by the residual effects of sub-pixel clouds, prolonged cloudiness, persistent haze, and bidirectional reflectance variation. We identify these contaminated NDVI pixels using 5th polynomial regression function. First process is comparing NDVI with newly produced NDVI that was derived from 5th polynomial regression coefficients. Then, we choose a higher NDVI value between newly reproduced NDVI using 5th polynomial regression and original NDVI. If newly reproduced value is lower than non-processed NDVI, we choose a non-processed NDVI because the higher value considered true. After comparing all of two NDVI, 1-th reproduced NDVI value was determined by choosing higher value NDVI. Then 1-th reproduced NDVI was again performed using 5th polynomial regression. Those processing was iterated 7 times, because 7 times processing were optimized for identification of contaminated pixels in previous study. Fig. 3 shows the result of NDVI correction of any pixel in study area. The corrected NDVI has the higher value than non-corrected NDVI. These corrections of NDVI profile improved the quality of classification.

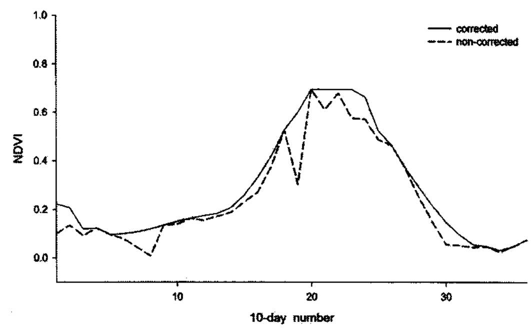

Fig. 3. Comparison of the corrected NDVI time series with original NDVI time series in 2000

3. RESULT

Fig. 4 shows NDVI time series of 2001 for eight classes. This NDVI time-series of the 10-day composites indicates a distinct seasonal pattern for different vegetation types. The NDVI values of class 1 and class 2 are significantly lower than other classes and have the least variation in the amplitude as barren areas while

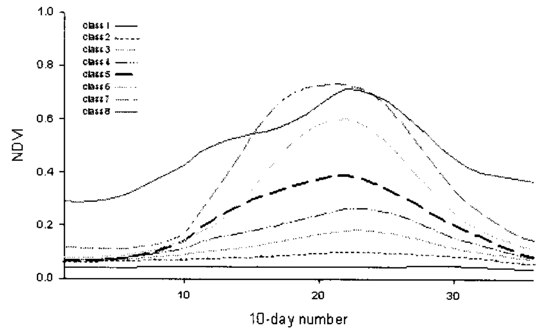

Fig. 4. Time series of NDVI profile in 2001

NDVI of vegetated areas began to increase in May and decreased in October with a peak in July and August. Class 8 with two harvests showed more than one NDVI peak while all other vegetation classes had only one peak.

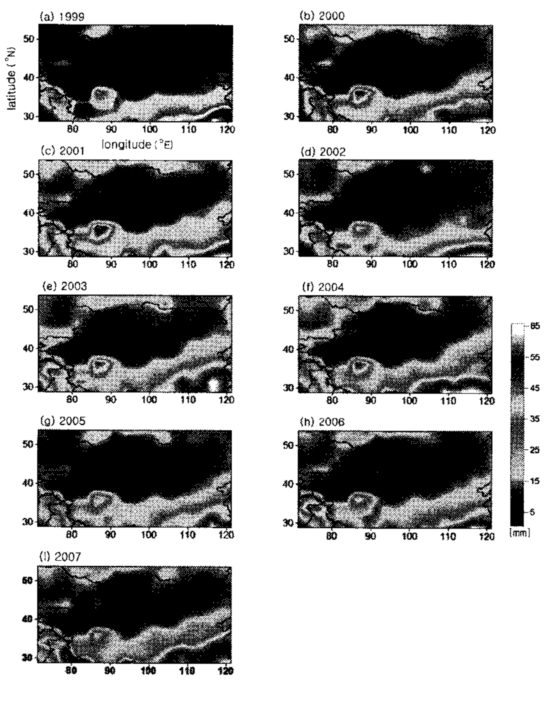

Fig. 5. Total yearly precipitation pattern from 1999 to 2007

Vegetation change is related to climate factor such as temperature and precipitation. Many studies have explored the relationship between variability of vegetation and climate data (Fangfang et al., 2003, Sudipta and Kafatos 2004, Maselli 2004 and Mingguo et al., 2006). Fig. 5 shows the total yearly precipitation patterns of each year (1999-2007). These patterns of precipitation are similar to our classification results. It is apparent that vegetation activities are affected by precipitation. There are little of rainfall around China's Gobi desert. Fig. 6 shows the inter-annual variations of average NDVI including total classes and total yearly precipitation per pixel. There is an increase of average NDVI value after 2005. The annual precipitation of 1999 is the least one for nine years. We didn't find any obvious link between variation of average NDVI and precipitation about the hole study area. Analysis of small scale is needed to find relation with precipitation.

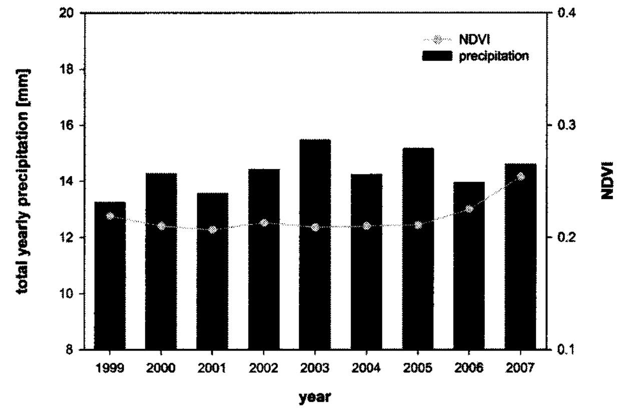

Fig. 6. Profile of yearly average NDVI and total yearly precipitation.

4. CONCLUSION

This study monitored the ecosystem surrounding the Gobi desert in North Asia using SPOT/VGT data with 1km resolution and analyzed quantitatively as well as qualitatively from 1999 to recent 2007. A monitoring vegetation was performed more closely to find out positive change as well as negative change. The vegetation cover has dramatically changed during the period 1999-2007 and there are significant extension of barren land between 1992 and 1999. However, some positive recoveries were catched in barren land after 2005. It seems to relate to social efforts of human and climate factor.

It is also apparent that precipitation factor has influence on the vegetation change like previous researches. Precipitation patterns are nearly similar to our classification results.

According to the numbers of study, the vegetation of North-east Asia has undergone considerable decrease over the last 30 years. It is apparent that climatic factors and humans activities have affected its vegetation condition. Therefore, monitoring the change of ecosystems is important for our global vegetation protection and we have to keep a careful watch on the problems related to ecosystems in this area constantly.

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