Characteristics of spatial-temporal changes of MODIS NDVI in Chinese Xilingol grassland from 2000 to 2008

Zhang Hongbin[a,b,c,1], Huang Qing [b,c,2],Yang Guixia[a,b,c,3], Li Gang[b,c,4], Chen Baorui[b,c,5],Xin Xiaoping[a,b,c,*]

[a] Hulunber Grassland Ecosystem Observation and Research Station, Beijing 100081, China

[b] Key Laboratory of Resource Remote Sensing and Digital Agriculture, Ministry of Agriculture, Beijing 100081, China

[c] Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, Beijing 100081, China

1 Objective

The goal of this paper is to investigate the recent spatial change trends of grassland vegetation, in Xilingol, Inner Mongolian, China. The previous researches on spatial-temporal character changes of grassland with long time series were mainly based on vegetation index production of NOAA AVHRR datasets. However, NOAA NDVI is inferior to MODIS NDVI in spatial and spectral resolution. And it is difficult to obtain (especially in recent years). Limited by remote sensing data sources, these researches on spatial-temporal characteristics changes of grassland with long time series were restricted in last 20 years of 20 century. Spatial-temporal orientation is deficient relatively. Especially, researches on spatial-temporal characteristics changes of grassland in recent years were very seldom (Liu et al., 2007). So time-series MODIS NDVI datasets were used in this study to investigate the characteristics of spatial-temporal changes in annual $NDVI_{max}$ for five typical grassland types, i.e., up-land meadow, low-land meadow, temperate meadow steppe, temperate steppe and steppe desert in Xinlingol grassland. And this paper provided basic science data and technology accumulation to evaluate the project of returning grazing land to pasture for government.

2 Methodology

Based on Vegetation Biomass and Coverage, Spatial-temporal Characteristics of Vegetation Index, Vegetation Phenology Characteristics, this paper used time-series MODIS NDVI datasets for 2000-2008 to investigate the characteristics of spatial-temporal changes in research region.

1. Vegetation Biomass and Coverage

Annual $NDVI_{max}$ is a direct embodiment of vegetation biomass and coverage (Xu et al., 2007; Steven et al., 2003; Cihlar et al., 1991). In biomass, this paper used annual $NDVI_{max}$ to represent annual accumulation of grassland biomass and coverage. Based on annual $NDVI_{max}$ and 1: 1,000,000 grassland type map of Xilingol league, taking advantage of Zonal Statistics in Spatial Analysis tools of ArcGis 9.0 software, annual mean $NDVI_{max}$ of up-land meadow, low-land

meadow, temperate meadow steppe, temperate steppe and steppe desert were calculated. Annual mean $NDVI_{max}$ was used to reflect annual biomass changes in 2000-2008. In vegetation coverage, spatial modeler of ERDAS 9.0 software was used to divide MODIS NDVI datasets into 5 grades, which were (0,0.2]、(0.2,0.4]、(0.4,0.6]、(0.6,0.8]、(0.8,1] respectively(Zhang et al., 2007). Different grade indicated different vegetation coverage. Area changes of different grades reflected trend of vegetation coverage.

2 Spatial-temporal Characteristics of Vegetation Index

The growth of grassland vegetation is easily affected by rainfall and temperature， which can cause NDVI to increase or to decrease in short-term, especially in those area of serious degenerated grasslands with annual herbs, where annual $NDVI_{max}$ is not suitable to be used to observe the vegetation change trend in long time series. Annual mean NDVI during growing seasons from 2000 to 2008 was used in this paper to represent vegetation growth condition. So every pixel of our composite images had corresponding 9 years time series NDVI. Slopes of NDVI revealed the trend of vegetation change during the 9 years. If the value of linear slope is more than 0, it means grassland is restored. On the contrary, if the value is less than 0, it means grassland is degenerated (Tucker et al., 2001). NDVI change trend of up-land meadow, low-land meadow, temperate meadow steppe, temperate steppe and steppe desert were calculated by formula 1，and through which the spatial change trend of different grassland types were reflected.

$$b = \frac{\sum_{i=1}^{n}(x_i - \bar{x})\ (y_i - \bar{y})}{\sum_{i=1}^{n}(x_i - \bar{x})^2} \qquad \text{Formula 1}$$

b : slope; x_i : i^{th} year mean NDVI $\bar{x}$: annual mean $NDVI_{max}$; y : year

Different type grassland is different in vegetation basic status and ecological carrying capacity. Fluctuation of annual $NDVI_{max}$ reflects human and natural disturbance condition in biomass and vegetation coverage. It's an important sign of grassland vegetation health condition. Big in fluctuation value means vegetation community is unstable (grassland is inclined to restore or degenerate); on the contrary, small in fluctuation value means vegetation community is stable. Standard deviation and coefficient of variation of 2000-2008 annual $NDVI_{max}$ were calculated by formula 2 and 3 to reflect the absolute variation and relative fluctuation degree of different types' vegetation in research area (Zhang et al., 2006; Myneni et al., 1998; Chen et al., 2007).

$$S=\sqrt{\frac{\sum_{i=1}^{n}x_i^2-\frac{(\sum_{i=1}^{n}x_i)^2}{n}}{n}} \quad \text{Formula 2} \quad C_V=\frac{S}{\bar{x}}\times 100\% \quad \text{Formula 3}$$

S : standard deviation; x_i : i th year $NDVI_{max}$;; C_v :coefficient of variation

3 Vegetation Phenology Characteristics

The occurrence time of annual $NDVI_{max}$ indicates in a certain degree the occurrence time of maximum value of biomass and vegetation coverage of grassland, which is an important growth and development symbol of grassland community. SPATIAL MODELER tools of ERDAS 9.0 software was used to calculate occurrence time of up-land meadow, low-land meadow, temperate meadow steppe, temperate steppe and steppe desert, which reflected the phonological characteristics change process and rules (Ding and Chen, 2007; Li et al., 2006; Chen et al., 2000; Wu et al., 2009; Wen, 1998).

Result

The analysis focused on the spatial change trends, the standard deviations and the occurrence time point of annual NDVImax for the period of 2000-2008.The results indicated that too much utilization pressure was put on the eastern research region including up-land meadow, low-land meadow, temperate meadow steppe and the south and north part of temperate steppe; the effects of vegetation protection and restoration were remarkable in western research region including steppe desert and the centre part of temperate steppe(Fig.1 to Fig.3). All types of grasslands are stable in biomass except steppe desert. For the changes in grassland areas over different grades, the areas where $NDVI_{max}$ is between 0 and 0.4 are inclined to decrease and areas where $NDVI_{max}$ is between 0.4 and 1 are inclined to increase. Overall, the deteriorating grassland accounts for about 42.24% of the total area; the restoring grassland takes the rest. The study also showed that there was about 72.22% of grassland where the $NDVI_{max}$ occurs between the 193rd day and the 241st day in each year, indicating that this period is the most important growing season for Xilingol grassland.

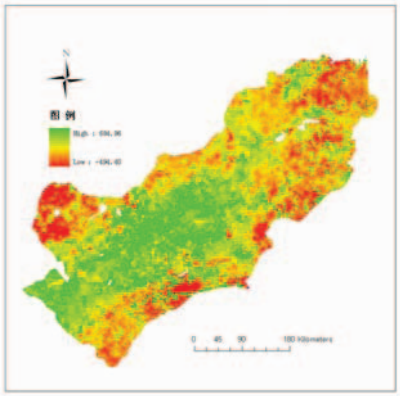

Fig.1 The slope of annual mean NDVI in Xilingol grassland from 2000 to 2008

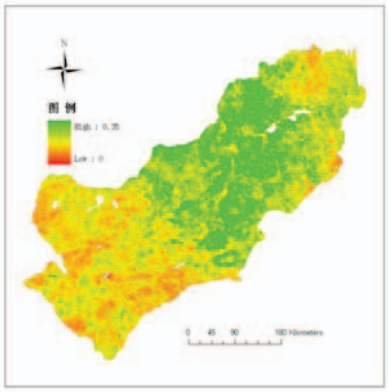

Fig.2 Annual standard deviation of grassland NDVImax in Xilingol from 2000 to 2008

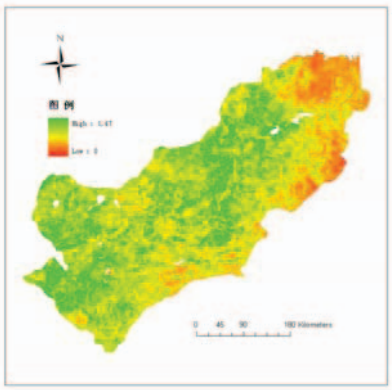

Fig.3 Annual coefficient of variation of grassland NDVImax in Xilingol from 2000 to 2008

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