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Vegetation change trend and its influencing factors in Mongolia

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Abstract: *Using the 1982-2015 GIMMS NDVI growing season (April-October) data, the average temperature and monthly precipitation data of 60 meteorological stations in the same period, the linear trend analysis method, the Mann-Kendall trend analysis method, the Pearson correlation the relationship between vegetation cover change and climate change in Mongolia and their response relationship were studied. The results show that in the past 34 years, the average NDVI of the growing season in Mongolia has gradually increased from south to north in space. From the seasonal point of view, the NDVI showed an increasing trend in all three seasons. From the impact of vegetation NDVI, the impact of precipitation on vegetation NDVI was greater than that of temperature. The response of different vegetation types to precipitation is greater than that of air temperature, and alpine grassland vegetation has a significantly effect on air temperature and precipitation.*

Keywords: *NDVI; vegetation type; air temperature; precipitation; temporal and spatial evolution characteristics*

1. Introduction

The relationship between global climate change and terrestrial ecosystems (global change and terrestrial ecosystem, GCTE) is one of the important contents of global change research [1]. Vegetation is an important part of terrestrial ecosystem, connecting soil, hydrosphere and atmosphere, promoting material migration and energy exchange in each circle, and playing an important role in climate regulation, terrestrial carbon cycle, soil and water conservation, etc. [2]. Climate change is one of the main factors that change the growth, structure and function of vegetation [3].

Mongolia is a major part of the Mongolian Plateau [4]. The southern part of Mongolia borders Inner Mongolia, China. Its ecological environment, natural resources, and social culture are closely related to China, and it is the most important green ecological barrier in northern China [5]. In addition, Mongolia is a country with a vast land and sparse population, and is one of the least populous countries in the world [6] (population density is 2 people/km2). Whether it is from geographical location, climate, ecosystem, or from human activities, the ecological pattern of the region and the in terms of the degree of influence and difference of the process, the region has certain regional characteristics. In recent years, Mongolia's terrestrial ecosystem has been significantly affected by climate change, such as lake area shrinking [7].

This study uses the third-generation NDVI (normalized difference vegetation index) data (NDVI3g) of the Global Inventory Modeling and Mapping Studies (GIMMS) from 1982 to 2015, combined with the temperature, precipitation and vegetation type data over the same period, to analyze On the basis of the interannual and seasonal variation characteristics of vegetation NDVI in Mongolia, its response to climate change was discussed. The purpose is to reveal the trend of vegetation growth and its main drivers in Mongolia at different temporal and spatial scales, and to provide a reference for understanding the overall development trend of the ecological environment in the region and for ecological environment construction and disaster prevention and mitigation.

1.1. Overview of the Study Area

In this paper, Mongolia is selected as the study area. Its geographical location is (41°35′-52°09′ N, 87°44′-119°56′ E), which is an inland plateau country and the second largest in the world. The landlocked country has a total land area of about 1.56 million km2. It borders the Siberia region of Russia in the north and the Inner Mongolia Autonomous Region of China in the south. The border with China is 4770

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km long. Mongolia's terrain gradually decreases from west to east, with an average elevation of 1580 meters, as shown in Figure 1.

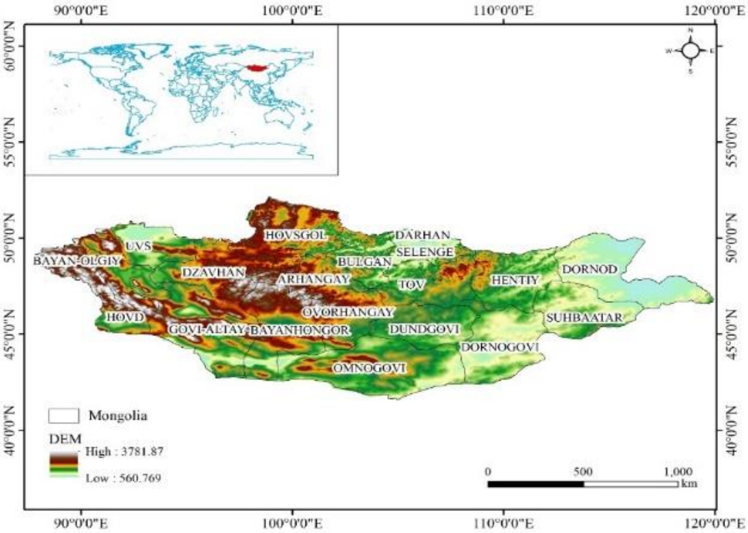

Figure 1: Location map of the study area

1.2. Data Sources and Methodology

1.2.1. Data sources

The meteorological data used in this study were provided by the School of Geographical Sciences, Inner Mongolia Normal University. For the monthly average temperature and monthly precipitation of 60 meteorological observation stations in Mongolia from April to October every year from 1982 to 2015, using the ArcGIS 10.2 environment, according to the geographical location of the meteorological station, using Kriging (Kriging) interpolation the temperature and precipitation data were processed by the method to obtain the rasterized monthly temperature and precipitation data with the same spatial resolution and projection as GIMMS NDVI, which were used for the research on the variation trend of NDVI at the pixel scale and its response to climate, as shown in Figure 2.

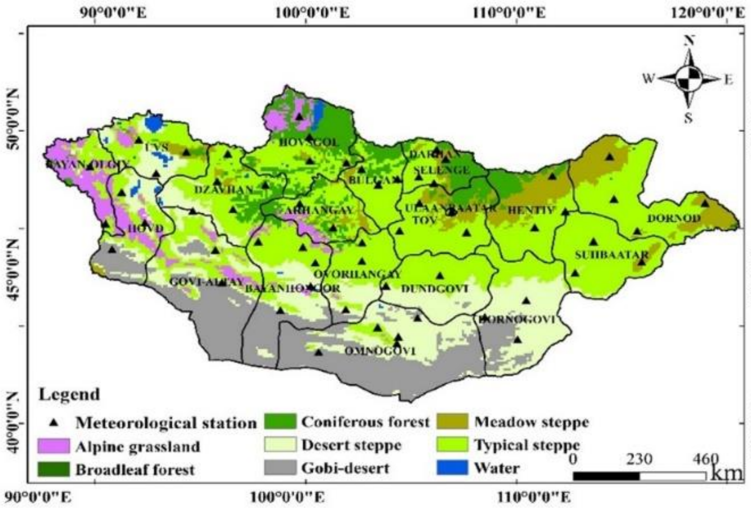

Figure 2: Weather site map

The vegetation type data comes from the Mongolian National Atlas. The vegetation type data in the atlas are scanned, geometrically corrected, digitized, etc., to obtain 6 vegetation types: alpine steppe, broad-leaved forest, coniferous forest meadow steppe, desert steppe, Gobi desert and typical steppe. Variation trends of vegetation types NDVI and their climatic responses. Livestock numbers and population data were obtained from the Mongolian National Statistical Information Service Network (http://www.1212.mn/).

The remote sensing data are GIMMS NDVI3g V1 data from 1982 to 2015 (https://ecocast.arc.nasa.gov/da-ta/pub/gimms/3g.v1/), the temporal and spatial resolutions are 15 d and 0.0833, respectively. Most of the vegetation in the study area stops growing in winter or is affected by snow cover. The NDVI data from April to October (the growing season) are selected for research every year. The maximum value synthesis processing was performed on the monthly two scene data to obtain a monthly-scale NDVI time series data set to further eliminate the influence of clouds, aerosols and other non-vegetation factors existing in the 15d NDVI. On this basis, the average value of NDVI from April to May, June to August and September to October was calculated to obtain NDVI in spring, summer and autumn, which was used to analyze the variation trend of NDVI in different seasons and its climate response. The average NDVI in the three growing seasons was further calculated to obtain the average NDVI in the growing season, and the temporal and spatial trend of annual NDVI was analyzed.

1.2.2. Methodology

Correlation analysis method

In order to study the controlling factors of meteorological factors on the vegetation cover changes in Mongolia, the correlation coefficient between meteorological factors and vegetation was obtained by correlation analysis to express the influence of climate on vegetation cover changes. And the t-test was used to test the significance of the correlation coefficient, and the calculation of the correlation coefficient was:

$$r_{xy} = \frac{\sum_{i=0}^{n}[(x_i-\bar{x})(y_i-\bar{y})]}{\sqrt{\sum_{i=1}^{n}(x_i-\bar{x})^2+\sum_{i=1}^{n}(y_i-\bar{y})^2}} \tag{1}$$

In the formula, the distribution of $\bar{x}$ and $\bar{y}$ is the average value of the sample values of the two elements. $r_{xy} > 0$ indicates a positive correlation, and $r_{xy} < 0$ indicates a negative correlation. The larger the correlation coefficient, the stronger the correlation between elements. The significance test of the two is realized by programming in Matlab, and the significance level mentioned in this study is 0.05.

2. Results

2.1. Change trend and climate response of vegetation NDVI in Mongolia

As shown in (Fig. 3a), it can be seen that in the past 34 years, the NDVI in the growing season in Mongolia has been fluctuating and rising slowly, with a linear upward trend of 0.004/10a. In 2012, it was 0.270, and the average over the years was 0.246. From 2000 to 2007, the vegetation NDVI showed a downward trend as a whole, and there were also years of continuous growth. As shown in (Fig. 3b), the fluctuation of vegetation NDVI in spring is frequent and significantly increased. The temperature reached a maximum of 5.58 ℃ in 1997, and reached -0.057 ℃ in 2010.As shown in (Fig. 3c), the vegetation NDVI in summer also has an increasing trend, but the linear upward trend is 0.003 mm/10a. The annual vegetation NDVI has the characteristics of continuous rise.As shown in (Fig. 3d), the vegetation NDVI volatility in autumn was smaller than that in spring and was significant. The temperature fluctuated greatly, and the temperature dropped greatly between 1998 and 2000.

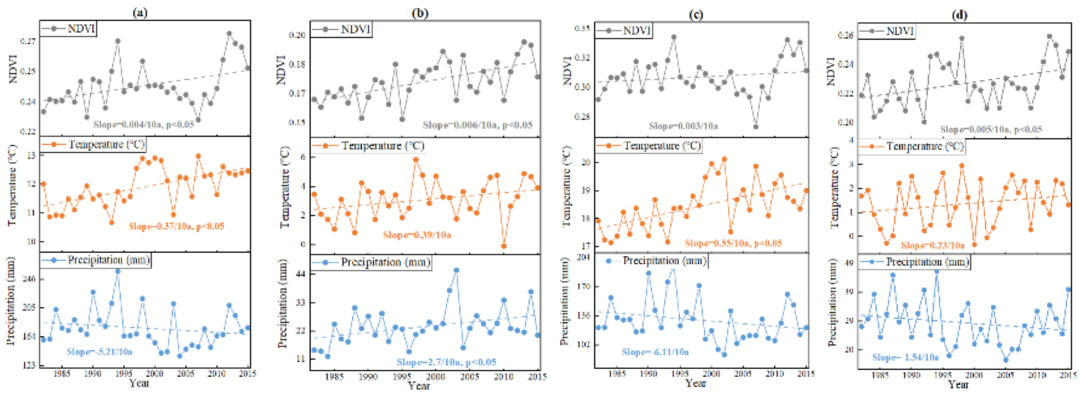

Figure 3: Variations of NDVI, temperature and precipitation during the growing season in Mongolia from 1982 to 2015 (a) in spring (b), summer (c) and autumn (d)

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2.2. Spatial pattern and climate response of vegetation NDVI variation trends in Mongolia

2.2.1. Spatial pattern of NDVI variation trends

The vegetation NDVI values in this area have different distribution characteristics at different times in the study period, the areas with a significant increase in vegetation coverage accounted for 29.35%, the areas with no significant increase in vegetation coverage accounted for 36.40%, and the areas with a significant decrease in vegetation coverage accounted for 8.8% (Fig. 4a). During the study period, the areas with reduced vegetation coverage in the spring Mongolia area decreased, and the areas with reduced vegetation coverage were mainly in the southwest area and a small part of the central area and receded significantly (Fig. 4b). The decline in vegetation coverage over time is moving north and the area is also expanding. The areas where vegetation coverage increases significantly are only in parts of the southwest of South Gobi Province and most of Oriental and Sukhbaatar Provinces. The vegetation in the area increased significantly (Fig. 4c). During the study period, the vegetation coverage in autumn is compared with that in summer. It can be seen that the area where the vegetation coverage decreases while the location changes, and the area where the vegetation coverage decreases is moving to the southeast and southwest. Only 21.5% of the areas with a significant increase in vegetation accounted for 44% without a significant increase (Fig. 4d).

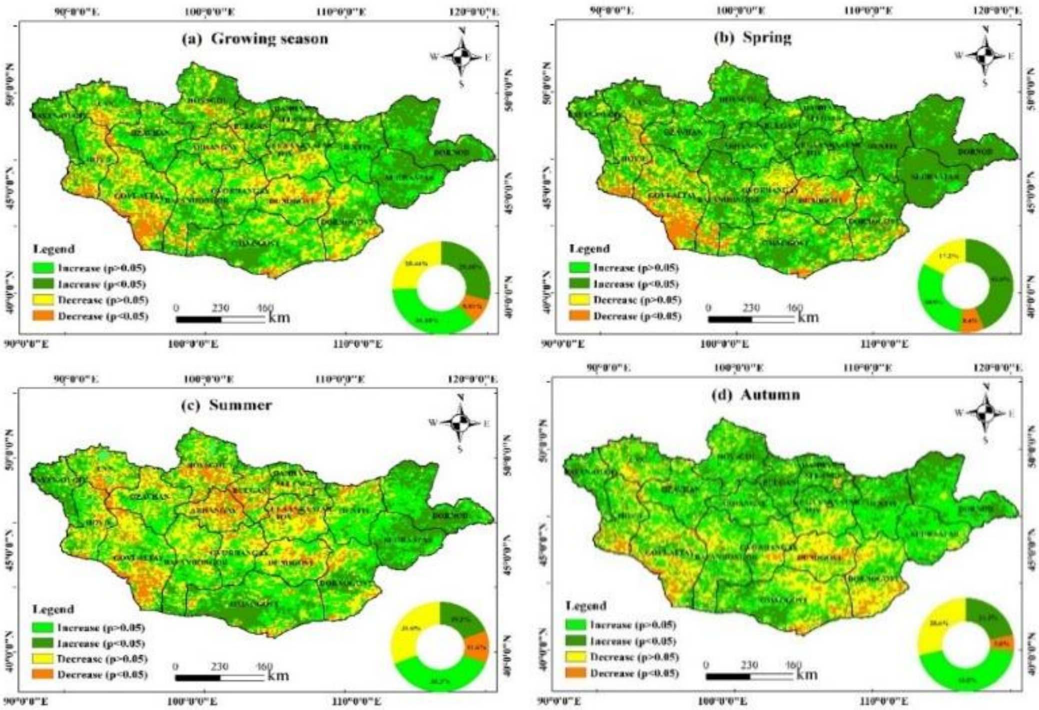

Figure 4: Spatial variation trend of vegetation NDVI

2.2.2. Spatial pattern of NDVI response to climate

As shown in Figure 5, The response of vegetation to temperature in the growing season is negatively correlated in most cases, and the proportion of pixels with negative correlation between NDVI and temperature in the growing season is as high as 60.9%, which is generally distributed in the central region; the negative response of vegetation NDVI to temperature is not significant. was 15.3%, mainly distributed in the central area of the study area (Fig. 5a). Compared with the NDVI in the growing season, the proportion of pixels positively correlated with NDVI in spring is 75.8%, and the overall distribution is in the northern, southern and southeastern regions, and the proportion of pixels passing the significance test of 0.05 is 29%. The distribution study area is in the northern and northwestern regions (Fig. 5b). It can be seen from the figure that the response of vegetation NDVI to temperature is more obvious in summer. The proportion of pixels negatively correlated with NDVI and temperature in summer is 75.1%, and the overall distribution is in the central area. The number of pixels passing the significance test of 0.05 accounts for 23.3%. %, mainly distributed in the central area of the study area (Fig. 5c). The proportion of pixels positively correlated with NDVI and temperature in autumn is 55.1%, and the overall distribution is in the northern and southern parts of Kusugur Province, and the proportion of pixels passing the significance test of 0.05 is 10.4%, mainly distributed in Kusugu Southern Ireland and

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northwestern Kent. (Fig. 5d)

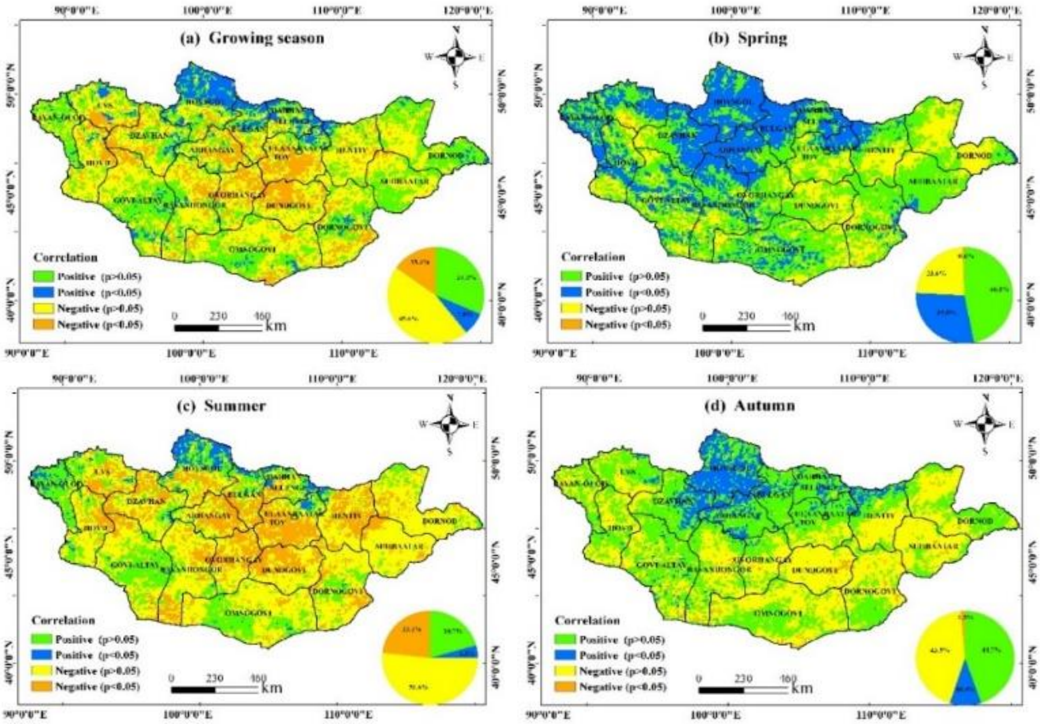

Figure 5: Correlation between vegetation NDVI and air temperature

2.3. Correlations between NDVI of different vegetation types and air temperature and precipitation

As shown in Figure 6, in Inner Mongolia, except for desert steppe, the other four vegetation types were positively correlated with air temperature throughout the growing season, among which coniferous forest was extremely significantly positively correlated. In the growing season and the other 3 seasons, coniferous forests are extremely significantly positively correlated, and in autumn, all five vegetation types are positively correlated, among which coniferous forests are extremely significant positive correlations, The coniferous forest had the most significant relationship with air temperature in the growing season, spring and autumn, followed by the influence of alpine grassland on air temperature in spring, summer and autumn. Among the different vegetation types, the four seasons of meadow steppe and desert steppe had no significant characteristics in response to air temperature. Then, to analyze the correlation between different vegetation and precipitation in different seasons, desert steppe and meadow steppe have a very significant positive correlation with precipitation in the growing season and summer, while the NDVI of coniferous forest vegetation and the growth season have a negative correlation with precipitation (-0.29), the remaining vegetation types were positively correlated. The relationship between different vegetation types and summer precipitation was the most significant, followed by the effect of growing season precipitation on different vegetation types.

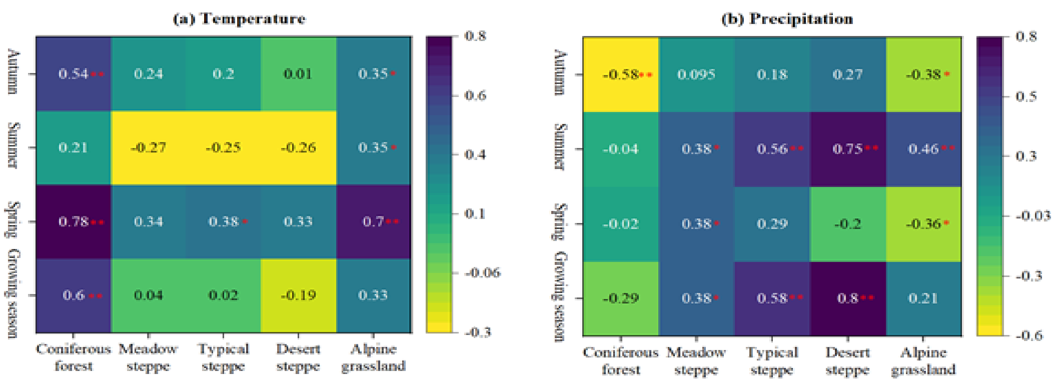

Figure 6: Partial correlation between NDVI and temperature and precipitation for different vegetation types

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3. Conclusion

This paper analyzes the vegetation cover change and climate response in Mongolia, and draws some preliminary conclusions. However, because the factors affecting vegetation cover are complex and diverse, the influencing factors are diverse, and the relationship between them is complex, with extensive and dynamic characteristics. It is difficult to describe the trend and interaction of climate change and vegetation cover change in a comprehensive analysis. And there are certain limitations in the data, and there are still some problems worthy of further study.

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