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Study on Dynamic Changes of Vegetation in Permafrost Region of Qinghai-Tibet Plateau —— Take the Area along Qinghai-Tibet Highway as an Example

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Abstract: Global warming leads to the degradation of permafrost in the Qinghai-Tibet Plateau, which has an important impact on the growth and distribution of its vegetation. However, the reduction and destruction of vegetation may lead to the degradation or disappearance of frozen soil, which will have a large-scale impact on engineering buildings and frozen soil ecological environment in cold regions. There is serious spatial heterogeneity in vegetation growth and change in permafrost regions of Qinghai-Tibet Plateau, so it is urgent to quantitatively study the process of surface vegetation change along Qinghai-Tibet Highway. In this study, MODIS data was used to study the characteristics of vegetation growth along the Qinghai-Tibet Plateau from 2000 to 2021, and it was found that the vegetation on the east side of the highway was better than that on the west side. On the whole, the vegetation growth from 2000 to 2021 showed a slight upward trend.

1. Introduction

With the global temperature increasing year by year in the past hundred years, the permafrost widely distributed in Qinghai-Tibet Plateau also has a serious degradation phenomenon, and according to the existing research, this trend will continue in the 21st century. The degradation of permafrost will increase the thickness of the active layer on it, which has an important influence on the growth and distribution of vegetation in permafrost region of Qinghai-Tibet Plateau. The Plateau ecosystem is particularly sensitive to climate change due to the existence of permafrost. The degradation of permafrost will change the water and thermal environment in the soil, and then affect the vegetation composition, species diversity, vegetation phenology and biomass in the alpine grassland ecosystem, and finally affect the carbon cycle process of the whole Qinghai Tibet Plateau, and affect the climate of surrounding areas and even the world.

At present, there are many research materials on the Qinghai-Tibet Plateau, and there are

different opinions on the response process of the alpine ecosystem to the freeze-thaw cycle. The desertification process of the alpine ecological environment with climate change, especially with the freezing and thawing process, is the top priority of environmental protection and academic research. In the context of global warming, the Qinghai-Tibet Plateau has experienced a significant warming process. According to the IPCC 2007 report, the average global temperature rose by 0.74±0.18 ℃ from 1906 to 2005. In the past 40 years alone, the average annual temperature growth rate of the Qinghai-Tibet Plateau has been 0.26 ℃ per decade, which is significantly higher than that of other regions. Intergovernmental Panel on Climate Change According to the climate report of IPCC, the global temperature is expected to rise by 1.8 - 4.0 ℃ by 2100. As a sensitive area to climate change, the permafrost in the Qinghai Tibet Plateau has also undergone obvious degradation. When the permafrost degradation is serious, the thermal melting of soil, such as thermal melting lakes and ponds, thermal melting collapse and thermal melting settlement, will lead to the impact on the engineering buildings and frozen soil ecological environment in the cold region Mass destruction.

Compared with other regions, the vegetation growth in permafrost regions is extremely fragile, and the vegetation growth basically begins in June or July and ends in October or even September. Moreover, the vegetation types in the Qinghai-Tibet Plateau are mainly grassland and meadow [1]. Shorter vegetation growth period, single vegetation type and less biomass (forest cover in the region is very scarce) make the vegetation growth in the permafrost area of the Qinghai Tibet Plateau more limited by environmental and climate change.

At present, the close mutual feeding relationship between biosphere and cryosphere is constantly strengthened under global changes [2]. On the one hand, ecosystem has a strong conservation function for cryosphere elements, on the other hand, different cryosphere elements have different action ways, modes and biological mechanisms for ecosystem.

The succession of plant communities in the Qinghai Tibet Plateau is very intense [2]. With the degradation of frozen soil, there was a serious degradation succession in the alpine grassland of the Qinghai Tibet Plateau from the 1980s to the 1990s and the first five years of the 21st century. The more significant plant growth advance in spring and delay in autumn, as well as the change of reproductive phenology on the Qinghai Tibet Plateau, have a negative effect on biodiversity [2]. Permafrost degradation will even affect the transformation of larger vegetation types, such as the change from forest to grassland [3]. Wang Genxu and others pointed out in 2006 that from 1986 to 2000, the area of alpine meadow in the Kunlun-Tanggula mountain section decreased by 7.98%, especially the alpine swamp meadow, which was highly sensitive to environmental disturbance, and even decreased by 28.11%. At the same time, the study [4] also pointed out that although the area of alpine grassland has expanded, the closeness between the grassland type and frozen soil environment is far lower than that of alpine meadow and alpine swamp meadow with significantly reduced area. In addition, it is also concluded that when the temperature rises by 2 ℃, the alpine meadow ecosystem in the study area will degrade to varying degrees in the next 50 years, and even serious degradation will occur in some areas. Zhang Yili et al. [5] found that the NDVI change of vegetation in the Koshi River Basin experienced three stages, with a growth rate of 0.001919 from 1982 to 1994, a decrease rate of 0.0058 from 1994 to 2000, and a growth rate of 0.0034 from 2000 to 2011. Luo Lihui et al. [6] worked on the Qinghai Tibet highway (Golmud to Lhasa) the dynamic changes of vegetation from 1982 to 2010 and from 2001 to 2010 were studied by using GIMMS NDVI and MODIS NDVI. Their annual growth rates were 0.0002 and 0.0021 respectively. However, GIMMS NDVI had obvious linear piecewise changes. The growth rate from 1982 to 2000 was 0.0010, but it decreased significantly by 0.0013 from 2001 to 2010. At the same time, this study tries to analyze the relationship between the change of active thickness and the change of vegetation. Finally, it is found that the degradation of permafrost has an adverse effect on the

growth of vegetation, and the reduction and destruction of vegetation may lead to the degradation or disappearance of permafrost. The above research results show that permafrost degradation will inevitably lead to more serious deterioration of ecological environment in permafrost regions of Qinghai-Tibet Plateau, and seriously affect the Qinghai-Tibet highway located on it.

However, some scholars have pointed out that with the global warming, the vegetation in some areas of permafrost region of Qinghai-Tibet Plateau also tends to be better. Gao Liming and Zhang Lele [7] studied the characteristics of vegetation growth in Qinghai Lake Basin from 2001 to 2017, and found that the overall vegetation coverage in the basin showed an upward trend, with an increase of about 3.2%/10a. However, this study also pointed out that although frozen soil degradation in Qinghai Lake Basin had little effect on the change of meadow and shrub vegetation coverage, frozen soil degradation caused the growth rate of grassland vegetation coverage to decrease by 1.2%/10a. Peng Jian et al. [8] analyzed the change trend of NDVI on the Qinghai Tibet Plateau from 1982 to 2003, found that the annual growth rate of NDVI was 0.0005, discussed the NDVI change rates of 7 vegetation types respectively, and finally found that only broad-leaved forest had a slight negative growth (0.0001).

Therefore, there is serious spatial heterogeneity in vegetation growth and change in permafrost region of Qinghai-Tibet Plateau. The growth and change of vegetation in different regions are quite different, so it is urgent to quantitatively study the process of surface vegetation change along Qinghai-Tibet Highway. This study uses MODIS NDVI data to analyze the vegetation change characteristics along Qinghai Tibet highway from February 2000 to September 2021. In addition, refer to more information to analyze natural factors (such as plateau pika) and human activities (overgrazing, grazing prohibition and protected areas) and consider their impact on vegetation growth.

2. Overview of the study area

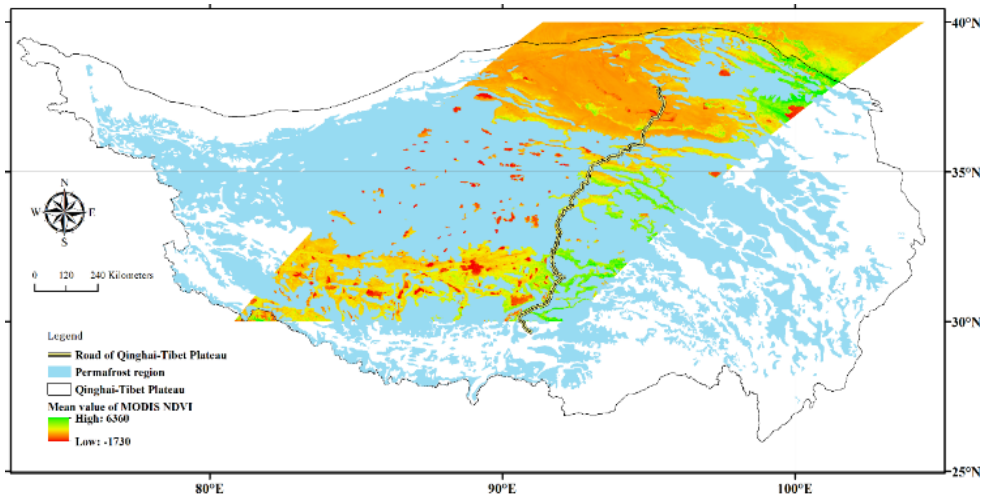

Figure 1: Schematic diagram of the study area

This study uses a complete MODIS image, as shown in Figure 1, covering the area along the Qinghai-Tibet Highway. The average altitude of the study area is over 4000 m, most of which is located in the permafrost region of the Qinghai-Tibet Plateau. The Qinghai Tibet highway in the study area is mainly from Golmud City to Lhasa City, including Kunlun Mountain (4600 m), Fenghuoshan (5010 m), Tanggula Mountain (5320 m), tou29 mountain (5180 m), chumar River, Hongliang River, Qushui River, Xiushui River, Beilu River, yamar River and Tongtian River, with a length of more than 1100 km.

3. Research method

3.1. Research data

In this study, MODIS13A3 dataset is used, which provides global sinusoidal projection grid products with a resolution of 1 km per month. As shown in Figure 1, the data image frame number used in this study is h25v05, and the coverage time range is from February 2000 to September 2021. It has been atmospheric corrected to remove the effects of water and cloud.

3.2. Data fetch

The original data is a data set in HDF file format, which needs to be processed by professional software before it can be used. For example, in this study, the Extract Subdataset tool in ArcGIS software is used to extract the NDVI layer in HDF file as the research image to complete the follow-up analysis.

3.3. Data statistical calculation

In this study, the average value and annual change rate of NDVI image layer images are mainly calculated, and the Cell Statistics tool in ArcGIS software is mainly used to calculate the average value of images. In addition, the annual change rate is completed by using the raster calculator tool in ArcGIS software.

3.4. Data geographic projection

After the above operation, the study image is not given geographical coordinates. Image is given as WGS 1984 projection coordinate system by Project Raster tool in ArcGIS software.

4. Research results

4.1. Multi-year average spatial distribution of NDVI along Qinghai Tibet highway

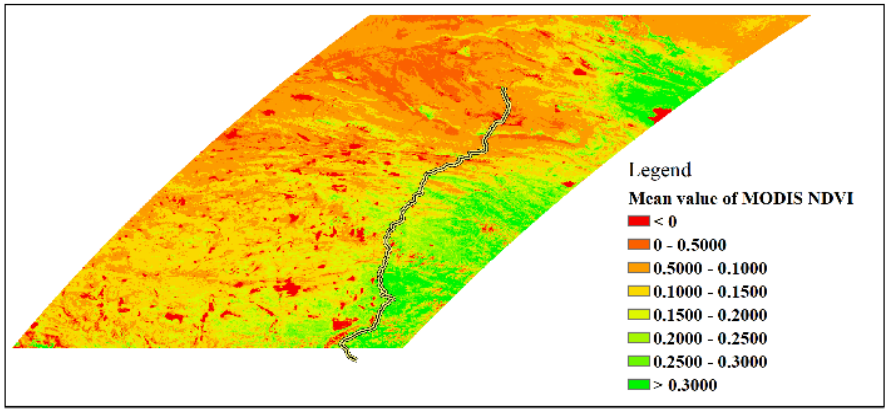

Figure 2: The spatial distribution of multi-year average NDVI in the area along the Qinghai-Tibet Highway from February 2000 to September 2021

Firstly, the average distribution of NDVI from February 2000 to September 20, 2021 is analyzed. As shown in figure 2. Generally speaking, the vegetation on the east side of Qinghai-Tibet Highway is better than that on the west side of the highway. The vegetation condition in the northwest of

Qinghai-Tibet Highway is the worst, with a low NDVI below 0.1. NDVI in southwest China is mostly between 0.1 and 0.2; The NDVI on the southeast side of Qinghai-Tibet Highway is relatively high, with most areas above 0.25.

4.2. Spatial distribution of annual change rate of NDVI along Qinghai Tibet highway

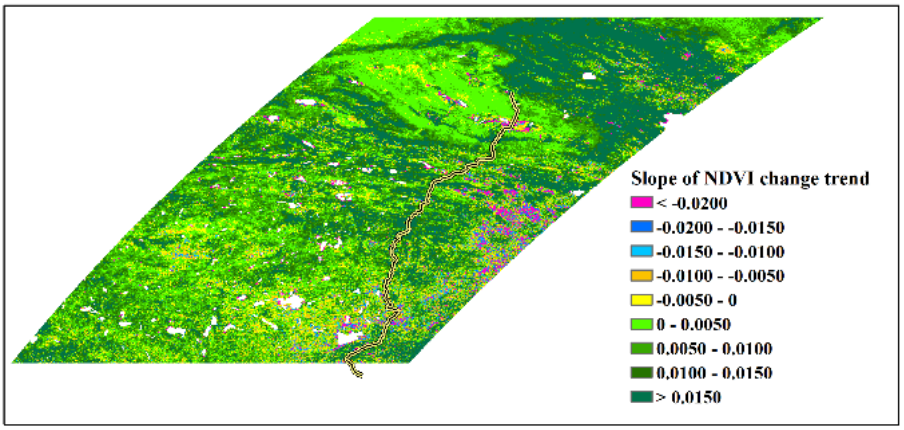

Figure 3: The spatial distribution of the annual NDVI change rate in the area along the Qinghai-Tibet Highway from 2000 to 2021

As shown in figure 3, during the period of 2000 -2021 along Qinghai-Tibet Highway, the overall vegetation growth showed a slight upward trend, and the growth rate in most regions was positive, but showed strong spatial heterogeneity. Among them, the trend of vegetation growth in the northeast of the highway is obvious, reaching 0.015/a. The areas with significant vegetation degradation are distributed on the east side of Qinghai-Tibet Highway, with a growth rate of-0.02/a. Other degraded areas are scattered in the west and northeast of the highway.

5. Conclusions

This study takes the Qinghai-Tibet Highway as the research area, and uses MODIS data to analyze the vegetation growth dynamics in the area. Generally speaking, the vegetation on the east side of Qinghai-Tibet Highway is better than that on the west side. From 2001 to 2021, there is a strong spatial heterogeneity of vegetation changes along the Qinghai-Tibet Highway. Among them, the trend of vegetation growth in the northeast of highway is obvious, and the degraded areas are mainly distributed in the east of Qinghai-Tibet highway. Overall, the vegetation growth along the Qinghai-Tibet Highway showed a slight upward trend during the study period.

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3). Guizhou forestry scientific research project Qianlin Kehe [2021] No. 10

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