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A Study of the Vegetation Growth Dynamics in the Three Rivers Source from 1982 to 2015

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Abstract: The three rivers source area (The source region of the Yangtze River, Yellow River and Lancang River) has the largest area of river source areas in China, and is also an important climate-sensitive area and ecologically fragile zone. Studies on its vegetation growth dynamics are of great significance to the construction of ecological security barriers in China and the construction of ecological civilization in the Qinghai-Tibet Plateau region. The study investigated the vegetation dynamics in the three rivers source area by using the GIMMS NDVI dataset from January 1982 to December 2015. The results show that the monthly NDVI and multi-year average spatial distribution of NDVI values in the three river source areas follow the same trend, with the NDVI values in the Lancang and Nujiang river basins being significantly larger than those in the Yangtze river basin; while the spatial distribution of NDVI annual change rates in the three river source areas is the opposite, with the annual NDVI change rates in the Yangtze river source area being better than those in the Lancang and Nujiang river basins.

1. Introduction

The three rivers source area is located in the southern part of Qinghai Province, with an average altitude of 3500 m above sea level, and is home to three major water systems: the Yangtze, Yellow and Lancang Rivers. Its ecological functions in terms of water containment and the growth of flora and fauna cannot be ignored. The high altitude of the region makes its perennial permafrost particularly developed. Permafrost is a state of frozen ground when the temperature of a material composition such as soil or rock on the earth's surface is maintained below 0°C [1]. When the surface remains below 0°C for at least two years or more, it is called Permafrost, when it remains frozen for half a month to several months it is called Seasonal Frozen Ground, and when it remains frozen for hours, days or even half a month it is called Short-Term Frozen Soil. Permafrost has also been defined as a geological body with negative temperatures, and permafrost as a layer of soil that remains frozen for two years or more. Permafrost covers about a quarter of the world's area and is

found mainly in the Northern Hemisphere, with permafrost found mainly in the circumpolar Arctic, Russia, Canada, the USA and China. Of this, permafrost covers a very large area of the global land surface, with 23.9% of the land surface in the Northern Hemisphere being permafrost zones [2]. Therefore, the surface of the three rivers source region of the Qinghai-Tibet Plateau, where permafrost is widely distributed, has unique hydrothermal properties.

In permafrost zones, where the Earth's surface material thaws in summer and freezes in winter in response to temperature changes, the near-surface environment is known as the Active Layer. As the temperature of permafrost increases, so does the thickness of the active layer. With this increase in the thickness of the active layer, the water and heat processes at the surface are greatly altered, which in turn affects the growth and development of vegetation. In recent years, the average annual temperature growth rate on the Qinghai-Tibet Plateau has been significantly higher than in other parts of China, resulting in a thinning of the permafrost and a thickening of the active layer. The changes in surface moisture and temperature conditions caused by the degradation of permafrost have a very significant impact on vegetation growth [3].

Located in the heart of the Qinghai-Tibet Plateau, the three rivers source is a climate-sensitive and ecologically fragile area [4]. Along with global warming, its ecological environment has undergone significant changes, such as perennial permafrost degradation, in addition to glacial retreat and shrinking wetland areas. There has been widespread interest in how the vegetation on which they are located has changed.

Currently, there are two main methods for analyzing vegetation trends: the first is field vegetation survey data[5], which is time-consuming and not suitable for vegetation studies over large areas; the other is remote sensing products[6], which have been increasingly used in multidisciplinary studies by virtue of their large area repeatability. One of the most representative datasets is the NDVI (Normalized Difference Vegetation Index), which is one of the most effective tools for monitoring vegetation growth[7], and is derived from the inversion of the visible red and near-infrared bands of the spectrum. This value is the ratio (in dimensionless units, between 0 and 1) of the infra-red band to the near-infrared band, and is highly correlated with the photosynthetically active radiation absorbed by vegetation, and is often used as a proxy for remote sensing parameters such as vegetation growth or biomass.

The revealing of characteristic patterns such as vegetation growth and changes in the three rivers source area is a fundamental data resource for accurately evaluating the ecology and environment of China's fragile areas, and will provide important data support for route selection planning, ecological and environmental impact assessment and protection of major construction projects in the three rivers source area, the Qinghai-Tibet Plateau area and even the multi-year permafrost zone in China. For these reasons, this study investigated the vegetation dynamics in the three rivers source area from January 1982 to December 2015 using the GIMMS NDVI dataset.

2. Overview of the study area

The three rivers source area is located in the hinterland of the Tibetan Plateau, with latitudes between 30-36°N and longitudes between 90-98°E, as shown in Figure 1. In Figure 1, the basin in the purple box in the north is the Yangtze River source basin, the basin in the black box in the south is the Nujiang River basin, and the basin in the red box in the east is the Lancang River basin. The study area ranges from 3200 m to 6700 m above sea level. The area is characterized by a typical highland continental climate, with alternating hot and cold seasons, distinct wet and dry seasons, small annual temperature differences, large daily temperature differences, long sunshine hours, strong radiation, and no clear distinction between the four seasons.

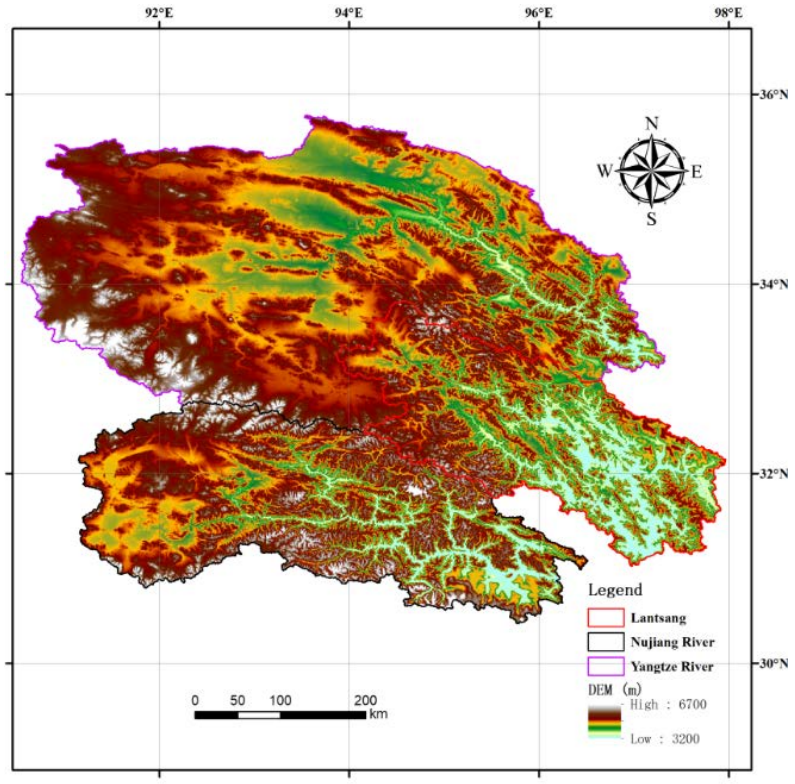

Figure 1: Overview of the region studied

3. Research Methodology

3.1. Study dataset

The data for this study are derived from the GIMMS NDVI 3g global dataset, covering the period July 1981 to December 2015, with a spatial resolution of 1/12° (~8 km) and a temporal resolution of 15 days. The data format is .nc4, with one nc4 file containing data for six months (January-June or July-December).

3.2. Data processing

In this study, only the complete time series of data from January 1982 to December 2015 were processed. First, the data were combined and averaged for the first and second half of the month to obtain the month data. After that, the data were averaged for each year to obtain the year-by-year NDVI mean data set from 1982 to 2015. Finally, the month-by-month data were geographically cropped to obtain the study area data.

4. Research Results

4.1. Month-to-month characteristics of NDVI in three rivers source

The overall year-by-year spatial distribution characteristics of the study area were similar for each month between 1982 and 2015, showing better vegetation growth in the southeast than in the northwest. In addition, the NDVI values in the Lancang and Nujiang river basins are significantly larger than those in the Yangtze River Basin, as shown in the 4-view image in Figure 2.

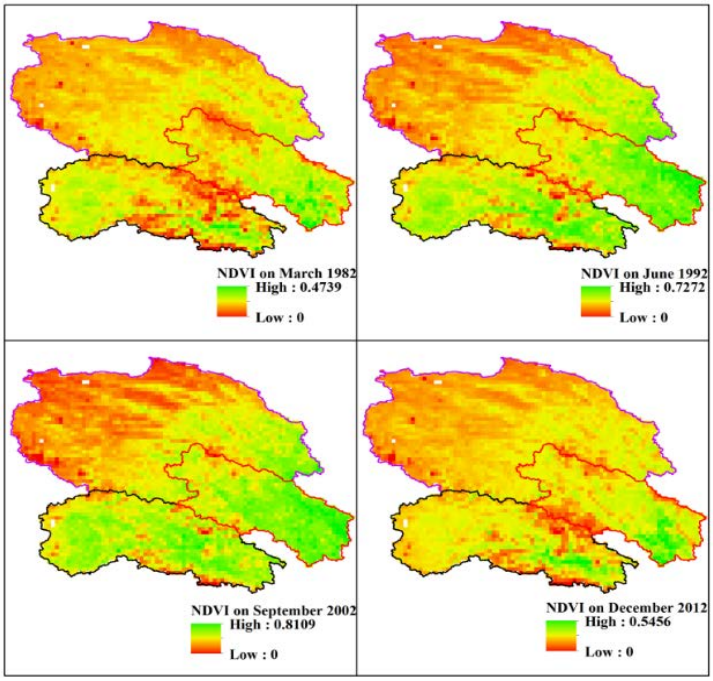

Figure 2: Month-by-month NDVI distribution in three rivers source (with March 1982, June 1992, September 2002 and December 2012 as examples)

4.2. Characteristics of the multi-year average spatial distribution of NDVI in three rivers source

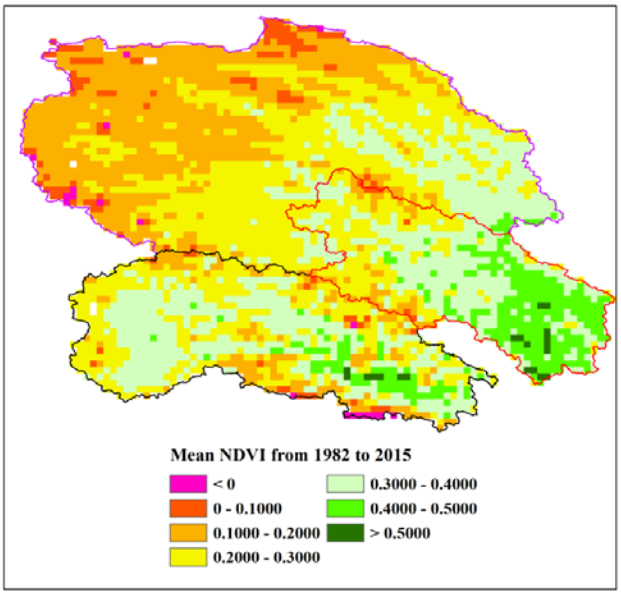

Figure 3: Spatial distribution characteristics of NDVI averages in the three rivers source area between 1982 and 2015

The spatial distribution characteristics of NDVI averages in the three rivers source area between 1982 and 2015 are shown in Figure 3, with NDVI values greater than 0.4000 mainly distributed in the Lancang and Nujiang river basins, and only a few areas in the eastern part of the Yangtze River source area with NDVI values greater than 0.4000. The NDVI values less than 0.1000 in the study

area are basically located in the Yangtze River Basin, with only sparse and scattered distribution in the Lancang and Nu River Basins.

4.3. Spatial distribution characteristics of the annual rate of change of NDVI in three rivers source

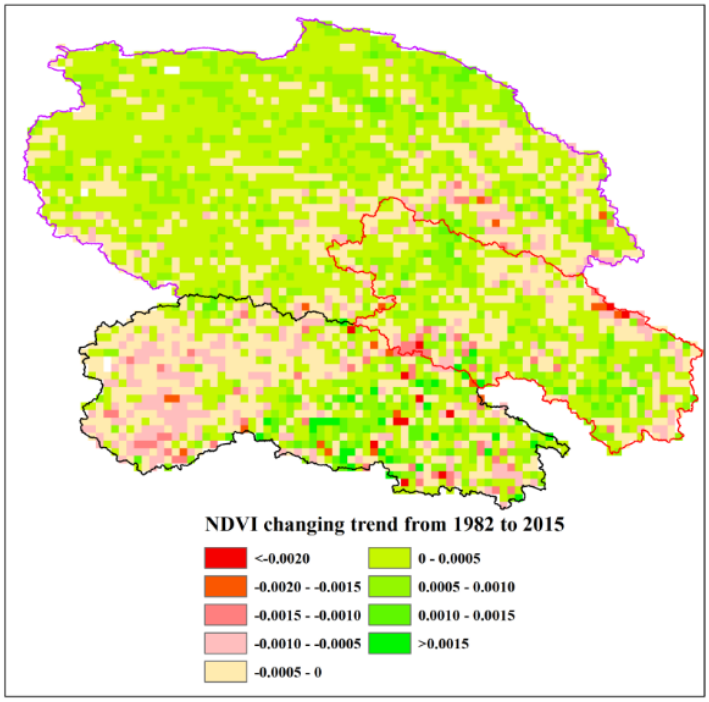

Figure 4: Spatial distribution characteristics of the annual rate of change of NDVI in three rivers source from 1982 to 2015

The spatial distribution characteristics of the NDVI annual variation rates in the three river sources are shown in Fig 4. The spatial distribution characteristics of the annual variation rates and the NDVI mean values in the study area are different, and the annual NDVI variation rates in the Yangtze River source area are instead better than those in the Lancang and Nujiang river basins.

5. Conclusion

A study of the NDVI distribution maps in the three rivers source areas shows that the monthly NDVI variability and the multi-year average spatial distribution of NDVI values in the three rivers source areas follow the same trend, with the NDVI values in the Lancang and Nujiang river basins being significantly larger than those in the Yangtze river basin, while the annual NDVI variability in the three river source areas is the opposite, with the annual NDVI variability in the Yangtze river source area being better than that in the Lancang and Nujiang river basins.

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