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Spatio-temporal distribution pattern of vegetation coverage in Junggar Basin, Xinjiang

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ABSTRACT

Vegetation coverage is an indicator used for exploring the growth of vegetation, which has attracted attention from ecologists owing to its significant role in ecological conservation and restoration. As an important component of the terrestrial ecosystem, changes in vegetation coverage reflect changes in the environment, especially with respect to arid areas. A change of vegetation coverage will trigger desertification, degradation of the eco-environment, and regional climate change. Hence, we studied the spatio-temporal distribution pattern of vegetation coverage and ephemerals in the Junggar Basin during the last few decades based on normalized difference vegetation index. The following conclusions were drawn. The vegetation coverage of the basin shows an overall upward trend, mainly because of the expansion of farmland. In particular, the southern rim has already formed an apparent continuous oasis belt, and the central part of the basin has low vegetation coverage due to a rugged environment but is relatively stable, whereas the northern part has a relatively small oasis distribution pattern. With respect to annual variation, the vegetation coverage of the basin reached the peak in July of every year, whereas the peak in the desert was in May or June; ephemeral plants clearly flourished during this phase. Ephemeral plants were distributed in the whole basin; the most prosperous region was the southern of the basin edge, and the plants decreased gradually from the edge to the center of the basin. The desert area of the central basin was the least prosperous area, but the southern and mid-eastern parts of the desert were prosperous. The expansion of the oasis has mainly had an impact on the 50-km range of the oasis edge, and the greatest impact is at the 5- to 20-km range of the oasis edge.

1. Introduction

With the intensifying trend of global change in recent decades, vegetation has attracted attention from ecologists owing to its significant role in ecological conservation and restoration and impact on climate change [1]. As an important component of the terrestrial ecosystem, vegetation has played a crucial role in material cycle and energy flow between atmosphere and terrestrial ecosystem via a series of complex biogeochemistry and geophysical processes [2,3].

As an index, vegetation coverage can reflect the status of vegetation growth, and its changes also with a series of complex ecological processes. Especially in arid areas, where changes in vegetation not only mirror evolvement of ecological environment, but also can trigger desertification [4], regional climate change [5], and environmental degradation [6]. For the investigation of vegetation coverage, traditional field study has been impossibly satisfied quantitative study at a large scale. In recent decades, with the popularization of remote sensing, it has been a convenient means using remote sensing data to monitor and analyze vegetation coverage [7]. Currently, most of the researches using remote sensing data to monitor changes of vegetation coverage were based on normalized difference vegetation index (NDVI) to estimate and analyze [8,9].

Junggar Basin is an economically important agricultural region in Xinjiang, so the use of remote sensing to monitor spatio-temporal changes in vegetation coverage at a macro-scale has an important meaning for the sustainable development of the economy and eco-environment. Hence, in this paper, using NDVI from 2000 to 2013 to analyze spatio-temporal distribution pattern of vegetation coverage and ephemerals in Junggar Basin of Xinjiang, our objectives were to provide some scientific basis for the protection and restoration of regional eco-environment.

2. Study area and methods

2.1. Study area

Junggar Basin is located in the northern Xinjiang Uyghur Autonomous Region of China. It is the second largest interior basin in China and is a representative area in the arid zone. It was found between the Tianshan Mountains and Altai Mountains, forming an irregular triangle, and its terrain tilts to the west. The southern edge of the basin is mainly oasis, and the vast Gurbantunggut Sandy Desert is distributed in the central part of the basin. The area has a typical temperate arid climate,

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with a low rate of annual rainfall and substantial evaporation, the winter and spring precipitation accounted for 30%–40% of the total annual precipitation. The soil is mainly desert lime soil and brown soil, with a low organic matter.

According to the 1:4,000,000 administrative map of China, topography map of Xinjiang, and descriptions of structure of Junggar Basin [10], we ascertain the scope of study area is a irregular triangle, with a 910 km east–west long and 426 km north–south wide.

2.2. Data sources and preprocessing

The data used in the study is MOD13Q1 (https://lpdaac.usgs.gov/) data provided by the Land Processes Distributed Active Archive Center (LP DAAC) of NASA, at a spatial resolution of 250 m with a 16-day time interval from 2000 to 2013. The dataset considered effects such as atmospheric calibration and geometric corrections.

For data preprocessing, the MODIS Reprojection Tool (MRT) provided by NASA was used to transform the format (HDF to TIFF) and projection (from Sinusoidal projection to Geographic Lat/Lon, WGS1984). The original DN values were transformed to NDVI. We also manipulated (prepossessed) the MOD13Q1 data subset via regions of interest (ROIs, vector border of study area) based on ENVI4.8 version software. Finally, the NDVI data was analyzed to determine the correlation between interannual trends and variances from 2000 to 2013. Furthermore, we used Maximum value composite (MVC) model to obtain the highest value for each pixel of 23 images during a year, and binary pixel model to estimate vegetation cover based on NDVI [11].

3. Results and analysis

3.1. Spatio-temporal distribution pattern of vegetation coverage in Junggar Basin

We preprocessed the MOD13Q1-NDVI data from the 2000 to 2013, and then estimated the vegetation cover of images based on the binary pixel model and MVC. According to the cumulative percentage of vegetation cover, we applied the decision tree method to classify the study region into the five threshold value ranges (0–0.09, 0.09–0.13, 0.13–0.2, 0.2–0.56, >0.56), which showed the distribution of vegetation cover for 2000 and 2013 in the Junggar Basin (Fig. 1).

It can be seen from Fig. 1, the highest vegetation coverage area of the basin was in the south and north, followed by the eastern region, with the midwest showing the lowest cover area. The highest cover area in the basin was in the south, which was due to the artificial oases distributed in the agricultural areas and the northern Tianshan Mountains from east to west, which are an important agricultural zone in Xinjiang. The western artificial oases distributed along the Manas River basin.

In addition, we found that artificial oases area obviously expanded to the central desert from 2000 to 2013. In 2000, the highest cover area mainly distributed along the national road and Manas River basin, with a zonal distribution, while in 2013, artificial oases in Manas River basin has been increased obviously into a patchy distribution, especially expansion of artificial oases in Karamay. According to data statistics, artificial oases in Xinjiang increased from 13,000 km^2 in 1953 to 61,900 in 2000 (about 5 times increase). During the research period, red region in vegetation coverage classification figure increased gradually, which may be related to the reclamation of new cropland. Since 1998, with the popularization of drip irrigation, as well as the increased price of cotton and policy-induced economy, farmers in Manas River basin have planted large amounts of cash crops to increase economic returns [12]. Qin et al. [13] studied spatio-temporal changes in cropland in northern China, and showed that significant cropland expansion occurred in Xinjiang from 2000 to 2010. Moreover, we found that the other classes were not fixed, with no distribution pattern being apparent. In particular, the 0.2–0.56 and 0.13–0.2 classes in the central desert increased obviously from 2000 to 2013, it illustrated that natural vegetation in the central desert increased during this period, which was likely due to the increase of precipitation or ecological conservation, and it is hard to make this conclusion only according to images.

3.2. The inter-annual variability of vegetation coverage

The highest cover area of the basin mainly distributed in artificial oases area, changes of vegetation cover in artificial oases area were mainly affected by the human activities, while changes of natural vegetation in the basin were mainly related to climate change. Hence, according to observational data of rainfall provided by National Meteorological Information Center of China, we counted the average annual precipitation of six meteorological stations (including Urumchi, Hebukesaier, Karamay, Jinghe, Wulanwusu, Qitai) in study area (Fig. 2b). For the inter-annual

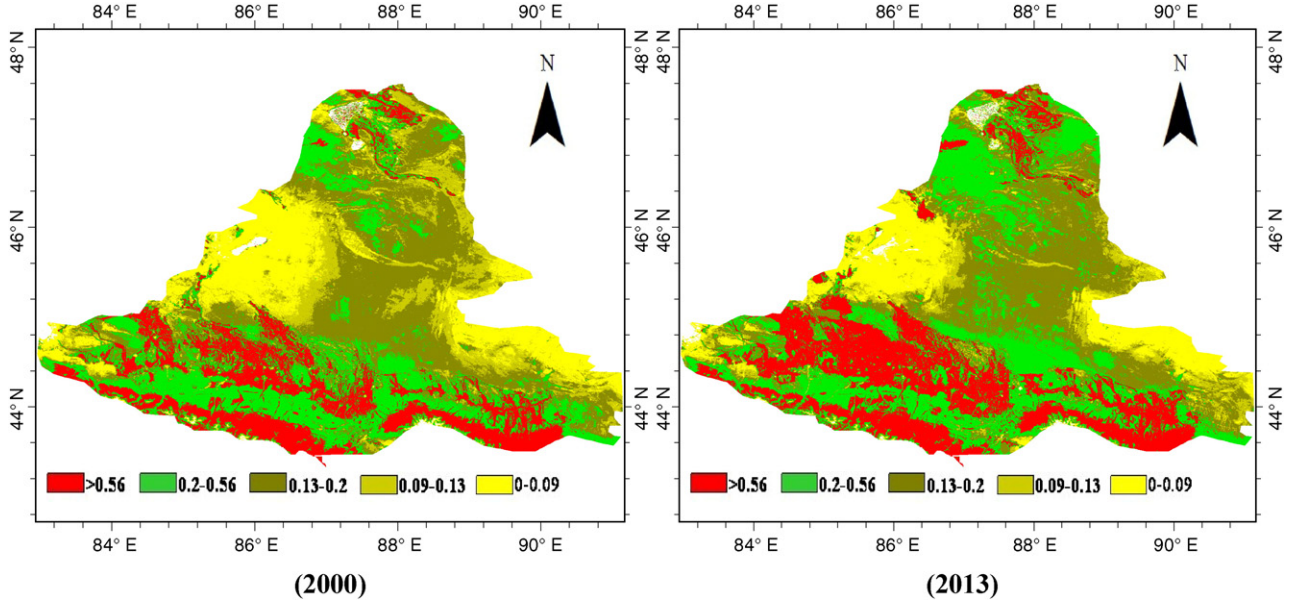

Fig. 1. Vegetation coverage in Junggar Basin classification figure. Classification of vegetation cover: 0–0.09 represents fixed desert with almost no vegetation; 0.09–0.13: fixed desert with little or sparse vegetation; 0.13–0.2: semi-fixed desert with low vegetation cover; 0.2–0.56: region with medium vegetation cover; >0.56: region with high vegetation cover, such as forests, grassland, and artificial oases.