Dynamic Changes of Aboveground Biomass of Vegetation in Qaidam Basin

Yu’è Du¹, Weiguo He²*, Jianping Zhou¹, Songyao Ma¹, Jun Yuan¹ and Yagang Wang¹

¹ Gansu Natural Energy Research Institute, Lanxhou, 730046, China
²*Corresponding author at: Information Science School, Guangdong University of Finance & Economics, Guangzhou, 510320, China.
E-mail address: jarbei@163.com

Abstract. In order to monitor the temporal and spatial dynamics of vegetation in the Qaidam Basin, the ground-based vegetation biomass model of the basin was established by using basin ground measurements data during 2016-2018 and NDVI of MOD13Q1: \( Y=0.0002X^2-0.863X+2052.4 \) \((R^2=0.7656,P<0.01)\), and using this model to estimate the long-term aboveground biomass data set of the vegetation of basin. Above-ground biomass of vegetation is mainly low-yield vegetation of less than 1500 kg/hm², followed by vegetation of 1500-3000 kg/hm², the area of which accounts for less than 10% of the total vegetation area, and the vegetation of the other levels is very small, only scattered. High-yield vegetation which is greater than 6000 kg/hm² is distributed in the southeast of the basin and in the alpine mountains around the basin.

1. Introduction

As one of the most important members of terrestrial ecosystems, vegetation is a sensitive variable that affects the energy balance. It has an impact on the hydrological, climatic, and biogeochemical cycles and is an indicator of climate change. The Normalized Vegetation Index (NDVI) is sensitive to the response of green vegetation and is often used to study and evaluate the growth and development of vegetation. It is a dimensionless ratio parameter that can use the near-infrared and red light bands of satellite image data to calculate NDVI value. The traditional vegetation monitoring method usually uses the field sampling method. This method requires a lot of manpower and material resources. The remote sensing technology has a wide application range, which is not only convenient and fast but also an effective method for large-scale vegetation monitoring.

Many foreign scholars have done a lot of researches on the dynamic change of above-ground biomass of vegetation by using historical data of vegetation index. Tucker et al.[1] used the NOAA satellite vegetation index data to monitor the dynamic changes of vegetation in the Sahel region of Africa, and analyzed the vegetation coverage and drought changes; Cheng Yanli [2] monitored dynamic changes of grassland vegetation; Sun Honyu et al.[3] analyzed the temporal and spatial changes of vegetation by using NOAA-AVHRR NDVI data from 1985 to 1990 in China; Although they are more available about Landsat8 OLI data from the United States Land Resources Satellite Compared with the high-scoring domestic satellites launched by China in recent years, they have a relatively narrow width, a long transit cycle, and greatly affected by clouds. There are fewer clear-sky data and it is difficult to construct historical vegetation yields and the inversion model of the vegetation coverage in via of remote sensing. Therefore, it is of great significance to use the MODIS...
normalized difference vegetation index (NDVI) historical sequence data to invert the spatiotemporal dynamics changes of aboveground biomass of vegetation in basin.

2. Data Sources and Methods

2.1. Overview of the Study Area

The Qaidam Basin is a huge mountain basin on the northeastern edge of the Tibetan Plateau, ranging from 34° 41’ to 39° 20’ N and 87° 48’ to 99° 18’ E. It is one of the four major basins in China. The basin is slightly triangular and extends northwest-west-south-east-east. The northwest, northeast, and south sides are surrounded by the Altun Mountains, Qilian Mountains, and Kunlun Mountains, respectively. It is a closed inland basin with a total area of 276,000 km², secondly only to Sanjiangyuan area. The areas of natural and available grasslands in the basin account for 35.77% and 28.33% of the total area of the study area, respectively. The natural vegetation types are mainly temperate desert grassland.

2.2. Data Sources

For the ground measurement data, the study selects the vegetation in growing seasons of Delingha, Ulan, Dulan, Dachaidan, and Mangya, Qaidam Basin from 2016 to 2018, including the latitude and longitude of the study areas, grass vegetation coverage, grass height, and main plant species in Number, main vegetation name, total fresh ground weight, air-dry weight, etc.

The product data of MODIS-MOD13Q1 is from the U.S. Geological Survey (http://glovis.usgs.gov), The time and spatial resolution are 16d (the first day to the 353th day of each year) and 250m, the time period is the corresponding normalized vegetation index (NDVI) products (Table) in June, July, and August from 2002 to 2015. There are total 84 scenes during the period (Table); The 8 scenes high score satellite (GF -1 / WFV) image data are from China Resources Satellite Application Center from July 28 to August 4, 2017.

| Table 1. MOD13Q Vegetation Index Product Data for 16 Days per Month |
|---------------------------------|---------------------------------|---------------------------------|
| month | Corresponding days of the month | month | Corresponding days of the month |
| 1     | 1, 17                           | 7     | 193,209                        |
| 2     | 33, 49                          | 8     | 225,241                        |
| 3     | 65, 81                          | 9     | 257,273                        |
| 4     | 97,113                          | 10    | 289,305                        |
| 5     | 129,145                         | 11    | 321                            |
| 6     | 161,177                         | 12    | 337,353                        |

2.3. Data Processing Method

The size of the plot in the study area was set to 50 m × 50 m. Each plot is set up with a 5-point method. The intersection point of the two diagonal lines of the plot is used as the first sample point, and the 4 corner points of the plot are selected as the other 4 sample points, which size of the plot is 0.5. m × 0.5 m; MOD13Q1 data is used for projection conversion and data splicing using the MODIS special data processing tool MRT provided on the NASA website; then the grid calculator under the spatial analysis module in ArcGIS10.X is used to process the NDVI data of 2 phases in each month according to the maximum synthesis method (MVC). The maximum composite value image of the growing season is synthesized by of the maximum NDVI of the month from June to August; finally, according to study limited areas to cut the NDVI raster maps of all the months and all Maximum NDVI image in growing seasons in the Qaidam.
3. Result Analysis

3.1. Construction of Remote Sensing Monitoring Model for Above-ground Biomass of Vegetation

Above-ground biomass of vegetation is an important indicator to monitor the dynamic changes of vegetation resources. After removing some outliers, the statistical analysis software of SAS 10.0 was used to construct regressionly a univariate linear model, an exponential model, a logarithmic model, and a quadratic polynomial model. The statistical analysis about the correlation between fresh vegetation above ground biomass and vegetation index (NDVI) was performed on various plots measured in the study area from June to August in a year. As a result, in the four remote sensing monitoring models of above-ground biomass based on normalized vegetation index (NDVI), the correlation coefficient R² value is logarithmic model < index model < linear model < univariate quadratic polynomial model. The result indicates that the univariate quadratic polynomial model can better inverse the fresh weight of vegetation above ground (Figure 1). Therefore, the remote sensing inversion model of above-ground biomass of vegetation in the Qaidam Basin can be expressed as:

\[ Y = 0.0002X^2 - 0.863X + 2052.4 \]

Among them: Y is the fresh weight of above ground biomass of the vegetation; X is the normalized vegetation index (NDVI); N is the number of samples.

![Figure 1. Comparison of Different Regression Models for Vegetation Index and Fresh Biomass above Ground in the Qaidam Basin](image)

To check the accuracy of the model. The fresh weight data of the above-ground biomass of the 30 plots of the 120 plots of all the plots that were not involved in the model construction were selected and compared with the predicted values, which obtained from the preferred univariate polynomial model for comparison. The result indicates that the average error of the model is 19.47%, and its accuracy 80.53% (Figure 2).
3.2. Dynamic Changes of Vegetation Biomass in Qaidam Basin
By using EOS/MODIS satellite data from 2002 to 2015, monitoring results show that the aboveground biomass of the vegetation in the basin is mainly low-yield [4] vegetation of less than 1500 kg/hm², followed by vegetation of 1500-3000 kg/hm², which accounts for the total area of vegetation less than 10%, the vegetation area of the other grades is very small, only scattered sporadically, while the high-yield vegetation greater than 6000 kg/hm² is distributed in the southeastern part of the basin and in areas with high elevations around the basin; In the past 14 years, the area of low-yield vegetation in the Qaidam Basin that was less than 1500 kg/hm² showed an increasing trend of fluctuations[5], with a growth rate of 418.37 km²/a, followed by the growth rate of above-ground biomass [6] between 1500 and 3000 kg/hm², with an area growth rate of 111.32 km²/a. In addition, the aboveground of vegetation was the lowest in 2002, 2006, and 2008 in the basin, and the highest in 2012. In 2010, the aboveground biomass of vegetation was secondly only to 2012, and it belongs to high-yielding years [7] (Figures 3).

4. Conclusion and Discussion
The data analysis of remote sensing and ground observation of years shows that the vegetation biomass has undergone significant changes in the Qaidam Basin. The specific conclusions are as follows:

(1) Aboveground biomass of vegetation is an important indicator for monitoring the dynamic changes of vegetation resources [8]. Among the four types of remote sensing monitoring models of above ground biomass based on the normalized vegetation index (NDVI) in the Qaidam Basin [9], the correlation coefficient R² logarithmic model <exponential model <linear model <univariate quadratic polynomial model, indicating a univariate quadratic polynomial model can better retrieve the fresh above ground biomass of vegetation. The remote sensing inversion model of aboveground biomass of basin vegetation can be expressed as: Y = 0.0002X²-0.863X + 2052.4
(2) The above-ground biomass of vegetation is mainly low-yield vegetation less than 1500 kg/hm², followed by vegetation of 1500 to 3000 kg/hm², the area accounting for less than 10% of the total vegetation area, and the vegetation of the other levels is very small and only sporadic. Distribution, and high-yield vegetation greater than 6000kg /hm² is distributed in the southeast of the basin and the alpine mountains around the basin [10].

Grassland vegetation ground measurement data in the Qaidam Basin is relatively small, which affects the accuracy verification of the vegetation remote sensing monitoring model, and further affects the fine monitoring of the aboveground biomass of the vegetation in the basin. The Terra/Aqua satellite used for inversion of vegetation above-ground biomass is close to being scrapped [11]. What satellite data will be used in the future to replace the MODIS satellite for the construction of long-range vegetation above-ground biomass datasets and data assimilation between different satellite data at different periods? In the follow-up research, we will consider using FY-3D and FY-4 satellites with similar channel value recently launched lues and high calibration and positioning accuracy. We can use the visible light data and the ground measurement data to construct a vegetation aboveground biomass monitoring model to solve the problem of MODIS satellites being discarded at any time. In view of the inconsistency between the ground vegetation sample monitoring and the satellite transit time, which affects the accuracy of the vegetation monitoring model, in future research, in addition to selecting monitoring satellites to perform ground vegetation sampling measurements in time when local transit is in place, it is also possible to use drones in real time Aerial vegetation plots are used to improve the monitoring accuracy of above-ground biomass of vegetation.

5. References
[1] Tucker C. J., Townshend JRG, Gofr TE. African land-Cover classification using satellite data [J]. Science, 1985, 227: 369-375.
[2] Chen Yanli, Long Buju, Pan Xuebiao, et al. Monitoring of grassland vegetation changes based on MODIS NDVI and climate information [J]. Journal of Applied Meteorology, 2010, 21 (2): 229-236.
[3] SunHongyu,WangChangyao,NIUZheng,etal.The Change of Surface Vegetation Coverage and Its Relationship with Environmental Factors in China: Analysis Based on NOAA Time Series Data [J]. Institute of Remote Sensing Applications, Chinese Academy of Sciences, 1998, 2(3):204-210.
[4] Xu Bin, Yang Xiuchun, Tao Weiguo, etc., Remote Sensing Monitoring of Grassland Yield in China [J]. Acta Ecologica Sinica, 2007, 27 (2): 405-413.
[5] Ma Wenhong, Fang Jingyun, Yang Yuanhe, et al. Biomass dynamics of grassland in North China and its relationship with climate factors [J]. Science in China: Life Sciences, 2010 (7): 632-641.
[6] Zhou Yuting, Fu Gang, Shen Zhenxi, et al. Remote sensing estimation model of aboveground biomass in a typical alpine meadow in northern Tibet [J]. Acta Prasae, 2013,22 (1): 120-129.
[7] SENicholson, MLDavenport, and ARMalo. A comparison of the vegetation response to rainfall in the sahel and east Africa, using normalized difference vegetation index from NOAA-AVHRR [J]. Climate Change, 1990, 17: 209- 241.
[8] Zhu Wenbin, Spatial differentiation of vegetation and its influencing factors in Qaidam Basin based on NDVI [J].Arid Land Research, 2010,27 (5): 691-698.
[9] Shi Yue, Ma Yinlei, Ma Wenhong, et al. Grass yield and forage quality in Chinese grasslands: patterns and their relationship with environmental factors [J]. Chinese Science Bulletin, 2013, 58 (3): 226.
[10] Wang Xiaolin. Spatial distribution characteristics of vegetation in Qaidam Basin [J]. China University of Geosciences (Beijing), 2012.
[11] Jin Xiaomei, Wang Songtao, Xia Wei. Study on the response of vegetation to climate and groundwater changes in Qaidam Basin [J]. Hydrogeology and Engineering Geology, 2016, 43 (2): 31-36.