J. Geogr. Sci. 2014, 24(4): 689-702
DOI: 10.1007/s11442-014-1113-3

Spatial-temporal characteristics of lake area variations in Hoh Xil region from 1970 to 2011

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Abstract: As one of the areas with numerous lakes on the Tibetan Plateau, the Hoh Xil region plays an extremely important role in the fragile plateau eco-environment. Based on topographic maps in the 1970s and Landsat TM/ETM+ remote sensing images in the 1990s and the period from 2000 to 2011, the data of 83 lakes with an area above 10 km^2 each were obtained by digitization method and artificial visual interpretation technology, and the causes for lake variations were also analyzed. Some conclusions can be drawn as follows. (1) From the 1970s to 2011, the lakes in the Hoh Xil region firstly shrank and then expanded. In particular, the area of lakes generally decreased during the 1970s–1990s. Then the lakes expanded from the 1990s to 2000 and the area was slightly higher than that in the 1970s. The area of lakes dramatically increased after 2000. (2) From 2000 to 2011, the lakes with different area ranks in the Hoh Xil region showed an overall expansion trend. Meanwhile, some regional differences were also discovered. Most of the lakes expanded and were widely distributed in the northern, central and western parts of the region. Some lakes were merged together or overflowed due to their rapid expansion. A small number of lakes with the trend of area decrease or strong fluctuation were scattered in the central and southern parts of the study area. And their variations were related to their own supply conditions or hydraulic connection with the downstream lakes or rivers. (3) The increase in precipitation was the dominant factor resulting in the expansion of lakes in the Hoh Xil region. The secondary factor was the increase in meltwater from glaciers and frozen soil due to climate warming.

Keywords: lake variation; spatial-temporal characteristics; Hoh Xil region; Tibetan Plateau

1 Introduction

As lakes are the important components of terrestrial hydrosphere, their area changes are the comprehensive result of water volume balance in the watershed and can factually record the information of climate change and human activity in lake area at different temporal scales.

Received: 2013-07-22 **Accepted:** 2013-08-29
Foundation: National Science-technology Support Plan Project, No.2012BAC19B07; National Natural Science Foundation of China, No.41071044; No.41261016; No.41190084; Youth Teacher Scientific Capability Promoting Project of Northwest Normal University, No.NWNU-LKQN-10-35
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Modeling the hydrological response to climate change in a glacierized high mountain region, northwest China

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ABSTRACT. The impact of climate change on the variability of local discharge was investigated in a glacierized high mountain catchment located in the source area of the Ürümqi river, northwest China. We used past climate records to drive a hydrological model to simulate the discharge from 2000 to 2008. The model was then used to project future discharge variations for the period 2041–60, based on a regionally downscaled climate-change scenario combined with three stages of glacier coverage (i.e. compared to the glacier coverage in 2008): unchanged glacier size (100% glacierized), recession of half the glacier area (50% glacierized) and complete disappearance of glaciers (0% glacierized). In each scenario, snowmelt will begin half a month earlier and the discharge will increase in May. For the 100% glacierized scenario, the discharge will increase by 66 ± 35% in a smaller (3.34 km^2) and more glaciated (50%) catchment and 33 ± 20% in a larger (28.90 km^2) and proportionally less glaciated (18%) catchment. If the glacier area reduces by half, the discharge will decrease by 8 ± 5% and 9 ± 6%, respectively. Once the glacier disappears, the discharge will decrease by 58 ± 20% and 40 ± 13%, respectively. Together, the results indicate that a warming climate and the resulting glacier shrinkage will cause significant changes in the volume and timing of runoff.

KEYWORDS: climate change, glacier hydrology, mountain glaciers

INTRODUCTION

Glaciated high mountainous areas are source regions for many important rivers around the world. These 'water towers' supply water to the surrounding lowlands and have even greater significance in arid regions, especially under the influence of climate warming (Viviroli and others, 2007; Immerzeel and others, 2010). As in many mountain regions worldwide, the majority of mountain glaciers in China are currently in a state of rapid retreat and thinning (Liu and others, 1999, 2006; Shangguan and others, 2007). Over the past three decades, a strong pattern of deglaciation has occurred in the arid region of northwest China, with a 10–13.8% reduction in glacier area (Liu and others, 2003; Li and others, 2010a). The primary impact of these changes is exhibited through changes in discharge of glacier-fed rivers (Mark and Seltzer, 2003; Hagg and others, 2007). This is important because glacier melt helps to maintain streamflow during dry periods, whereas in non-glaciated basins, rivers would experience extremely low flow (Stahl and others, 2008).

According to the Intergovernmental Panel on Climate Change (IPCC), the predicted changes in temperature and precipitation are expected to cause mountain glaciers to retreat further during the 21st century, and in turn to substantially affect glacier melt and water availability (Solomon and others, 2007). We selected the Ürümqi river source region, a glaciated high mountain catchment in northwest China, as our study area. In this region, glaciers are relatively small, with an average area of <1 km^2, and are extremely sensitive to climate change. Li and others (2011) reported that from 1962 to 2008 the regional temperature increased by 1°C and the mass loss from Ürümqi glacier No. 1 (area 1.65 km^2 and length 2.23 km in 2009) was as much as 13.69 m. Given the relatively high sensitivity of smaller glaciers and the source area of the Ürümqi river as a major experimental base of cold region hydrology in China, with excellent glaciological, hydrological and meteorological monitoring records, our study site is highly useful for quantifying the magnitude and for clarifying the mechanisms of hydrological response processes in small glaciers under future climate conditions.

On a catchment scale, previous studies of the Ürümqi river source area have addressed the importance of glaciers and snowmelt and the potential effects of climate change on local hydrological regimes (Ye and others, 2005; Han and others, 2010; Li and others, 2010b; Sun and others, 2013). However, these results are mostly qualitative, and have not quantitatively evaluated the possible future changes in discharge. The objective of this research was to investigate how the water availability from this glaciated headwater might change by mid-century (2041–60) for three different scenarios of glacier coverage. First, we used the observed climate record to drive a hydrological model that simulated the discharge for the reference period 2000–08. The model was then used to predict future discharge variations, based on regionally downscaled climate change data. Such analyses are useful for evaluating the utilization of water resources and the development of appropriate watershed management strategies in the arid region of northwest China.

STUDY AREA

The Ürümqi river source region (43°05′–43°09′ N, 86°47′–86°53′ E; 3405–4486 m a.s.l.) is located on the northern side of the eastern Tien Shan, within the arid region of northwest China (Fig. 1). There are seven glaciers, with an area of

J. Geogr. Sci. 2015, 25(2): 149-164
DOI: 10.1007/s11442-015-1159-x

Hydrological processes of glacier and snow melting and runoff in the Urumqi River source region, eastern Tianshan Mountains, China

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Abstract: Hydrological processes were compared, with and without the influence of precipitation on discharge, to identify the differences between glacierized and non-glacierized catchments in the Urumqi River source region, on the northern slope of the eastern Tianshan Mountains, during the melting season (May–September) in 2011. The study was based on hydrological data observed at 10-min intervals, meteorological data observed at 15-min intervals, and glacier melting and snow observations from the Empty Cirque, Zongkong, and Urumqi Glacier No.1 gauging stations. The results indicated that the discharge differed markedly among the three gauging stations. The daily discharge was more than the nightly discharge at the Glacier No.1 gauging station, which contrasted with the patterns observed at the Zongkong and Empty Cirque gauging stations. There was a clear daily variation in the discharge at the three gauging stations, with differences in the magnitude and duration of the peak discharge. When precipitation was not considered, the time-lags between the maximum discharge and the highest temperature were 1–3 h, 10–16 h, and 5–11 h at the Glacier No.1, Empty Cirque, and Zongkong gauging stations, respectively. When precipitation was taken into consideration, the corresponding time-lags were 0–1 h, 13 h, and 6–7 h, respectively. Therefore, the duration from the generation of discharge to confluence was the shortest in the glacierized catchment and the longest in the catchment where was mainly covered by snow. It was also shown that the hydrological process from the generation of discharge to confluence shortened when precipitation was considered. The factors influencing changes in the discharge among the three gauging stations were different. For Glacier No.1 station, the discharge was mainly controlled by heat conditions in the glacierized region, and the discharge displayed an accelerated growth when the temperature exceeded 5°C in the melt season. It was found that the englacial and subglacial drainage channel of Glacier No.1 had become simpler during the past 20 years. Its weaker retardance and storage of glacier melting water resulted in rapid discharge confluence. It was also shown that the discharge curve and the

Received: 2014-08-29 **Accepted:** 2014-09-22
Foundation: National Science and Technology Support Plan Projects, No.2012BAC19B07; Scientific Research Project of Higher Learning Institution in Gansu Province, No.2013A-018; Project of Scientific Ability Promoting of Young Teachers of Northwest Normal University, No.NWNU- LKQN-12-20
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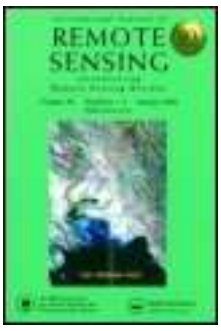

International Journal of Remote Sensing
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tres20

A method for estimating the gross primary production of alpine meadows using MODIS and climate data in China

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To cite this article: Fei Li, Xufeng Wang, Jun Zhao, Xiaoqiang Zhang & Qianjun Zhao (2013) A method for estimating the gross primary production of alpine meadows using MODIS and climate data in China, International Journal of Remote Sensing, 34:23, 8266-8286

To link to this article: http://dx.doi.org/10.1080/01431161.2013.834394

Quaternary International 349 (2014) 339–345

Contents lists available at ScienceDirect

Quaternary International

journal homepage: www.elsevier.com/locate/quaint

Changes of the three holy lakes in recent years and quantitative analysis of the influencing factors

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ARTICLE INFO

Article history:
Available online 16 May 2014

Keywords:
Lake water balance
Lake variation
The three holy lakes
Tibetan Plateau

ABSTRACT

Namco Lake, Yamzho Yumco Lake, and Mapam Yamco Lake are the "three holy lakes" of Tibet. Based on the topographic map of 1970 and the Landsat TM/ETM + remote sensing images of 1970 and from 1990 to 2012, satellite altimetry data, observed data from meteorological stations, and the changes of the "three holy lakes" in area, water level and water storage, the lake status and causes of the changes have been analyzed in a comparative manner. From 1970 to 2012, Namco Lake rapidly expanded in area, Yamzho Yumco Lake sharply declined, and Mapam Yamco Lake showed a slight decline with no great changes. The increase in precipitation was the main reason for the expansion of Namco Lake from 1970 to 1998, but the increase in glacial meltwater caused by temperature rise, and the decrease in evaporation from the lake surface, are the main reasons for the expansion and water storage increase of Namco Lake after 1998. Yamzho Yumco Lake significantly expanded from 1991 to 2004 mainly because the evaporation was limited, and shrank after 2004 because of the decrease in precipitation and the increase in evaporation. Mapam Yamco Lake was shrinking due to higher evaporation and lower precipitation. In addition to glacier meltwater, there are other forms of supply, such as groundwater, wetlands, and permafrost ablation.

1. Introduction

As an important part of the land hydrosphere, the change of the waters in a lake is the comprehensive results of the water balance within its river basin (Ding et al., 2006), and it is also a sensitive indicator of climate change (Lu et al., 2005). The lake area of Qinghai–Tibet Plateau is such an area of plateau lake groups that is highest in elevation, most in number and largest in area around the world (Ma et al., 2011). In recent years, the overall temperature on Qinghai–Tibet Plateau has increased (Wu et al., 2005; Holmes et al., 2009). With certain differences in spatial precipitation change, most areas have showed a trend of humidifying except eastern Tibet (Jiang et al., 2012). Since the 1980s, the glacial meltwater has increased as glaciers on the Plateau have retreated quickly (Shi et al., 2006). Influenced by these and other conditions, the number of lakes on the Plateau has increased, and the total area expanded. The southwest showed little change while the northeast showed expansion (Yan and Qi, 2012). The strong contraction or expansion of lakes has exerted a huge impact on natural environment and human life, and thus it has been attracting more and more attention (Shi, 1990; Yin et al., 2013).

Namco Lake, Yamzho Yumco Lake and Mapam Yamco Lake are called the "three holy lakes" of Tibet. They are the sites of the traditional "Lake Visiting Festival" of the Tibetan people and the grassland around them is a good natural pasture. Therefore, changes of the "three holy lakes" have been drawing people's attention. Under the background of climate warming, many scholars have carried out scientific research on Namco Lake, Yamzho Yumco Lake, and Mapam Yamco Lake in recent years. For example, Zhu et al. (2010) calculated the changes in the water volume of Namco Lake from 1970 to 2004, and found that both the area and the water volume showed a trend of increase in the past 34 years, accelerating from 1992 to 2004. Zhang et al. (2011) found that the water volume in Namco Lake increased by 114.214×10^8 m^3 from 1976 to 2009 using GLAS altimeter and measured data. Liu (1995) analyzed the variation in the water level of Yamzho Yumco Lake systematically and showed that the water level of the lake was slowly falling from 4441.04°m in 1974–4438.44°m in 1992 in this period. Chu et al. (2012) extended the time series of the lake's water level to 2009 and found that the water level of the lake had risen from 1996 to 2004, but it had

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http://dx.doi.org/10.1016/j.quaint.2014.04.051
1040-6182/

Article

Chinese Science Bulletin

Agronomy

April 2012 Vol.57 No.11: 1298–1310
doi: 10.1007/s11434-011-4870-8

Changes in global potential vegetation distributions from 1911 to 2000 as simulated by the Comprehensive Sequential Classification System approach

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Received July 18, 2011; accepted September 30, 2011; published online December 21, 2011

Vegetation classification models play an important role in studying the response of the terrestrial ecosystem to global climate change. In this paper, we study changes in global Potential Natural Vegetation (PNV) distributions using the Comprehensive Sequential Classification System (CSCS) approach, a technique that combines geographic information systems. Results indicate that on a global scale there are good agreements among maps produced by the CSCS method and the globally well-accepted Holdridge Life Zone (HLZ) and BIOME4 PNV models. The potential vegetation simulated by the CSCS approach has 6 major latitudinal zones in the northern hemisphere and 2 in the southern hemisphere. In mountainous areas it has obvious altitudinal distribution characteristics due to topographic effects. The distribution extent for different PNV classes at various periods has different characteristics. It had a decreasing trend for the tundra and alpine steppe, desert, sub-tropical forest and tropical forest categories, and an increasing trend for the temperate forest and grassland vegetation categories. The simulation of global CSCS-based PNV classes helps to understand climate-vegetation relationships and reveals the dynamics of potential vegetation distributions induced by global changes. Compared with existing statistical and equilibrium models, the CSCS approach provides similar mapping results for global PNV and has the advantage of improved simulation of grassland classes.

potential natural vegetation, spatial distribution, biogeography model, CSCS approach

Citation: Liang T G, Feng Q S, Cao J J, et al. Changes in global potential vegetation distributions from 1911 to 2000 as simulated by the Comprehensive Sequential Classification System approach. Chin Sci Bull, 2012, 57: 1298–1310, doi: 10.1007/s11434-011-4870-8

Global climate and environmental changes brought about by anthropogenic means and their potentially serious impact on global and local ecosystems are receiving enormous attention from scientists, governments and society in general [1]. The study of Potential Natural Vegetation (PNV) has been proposed as a way to examine the impact of climate changes on vegetation distributions [2,3]. To understand the spatial distribution patterns of PNV and their spatial and temporal repeatability is therefore a starting point for studying climate-vegetation relationships.

The separation of anthropogenic and non-anthropogenic influences on climate-vegetation relationships is complicated. Climate-vegetation classification or relationship studies, based on existing patterns of vegetation, can potentially enable the evaluation of societal impacts on relationships between climate and vegetation. Potential vegetation

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Intelligent Automation and Soft Computing, Vol. 16, No. 6, pp. 857-867, 2010

USE OF USLE/GIS TECHNOLOGY TO ASSESS SOIL WATER EROSION IN CHINESE LOESS HILLY AND GULLY REGION: A CASE STUDY OF THE WEIGOU RIVER BASIN, GANSU PROVINCE, CHINA

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ABSTRACT—Soil erosion is a serious environmental and production problem in China. To decrease the risk on environmental impacts, there is an increasing demand for sound, and readily applicable techniques for soil conservation planning in this area. This study was conducted at the Weigou River basin in northwestern China to predict annual soil loss using the RUSLE to determine the erosion hazard in the area and target locations for appropriate initiation of conservation measures. All factors used in RUSLE were calculated for the basin using local data. The rainfall erosivity R-factor was 607.4 MJ mm $ha^{-1}h^{-1}year^{-1}$ and the annual average soil erodibility *K*-factor has been drawn from the soil map. *LS* factor has been estimated according to the RUSLE model by using a 25-m square cell DEM. *C* factor has been derived by processing the data inferred from the land cover map, whose legend includes 12 different land uses type interpreted from remote sensing images. Support practice *P*-factors were from terraces that exist on slopes where crops is grown. Resulting soil loss map revealed that spatial average soil erosion at the basin was 95.59 t ha^{-1} $year^{-1}$ in 1998 and 93.4t ha^{-1} $year^{-1}$ in 2004, while the estimated sediment yield was found to be 280.92×10^4t and 274.60×10^4t respectively. Soil erosion is serious respectively from 15 to 25 of slope degree, elevation area from 1800 to 1900 meters, where is the particular area of soil and water loss prevention. As far as land use is concerned, soil losses are highest in dry crop land and those in resident area are second. The results of the study provide useful information for decision makers and planners to take appropriate land management measures in the area.

Key Words: soil water erosion, RUSLE, remote sensing and GIS, Loess Hilly & Gully Region, China

1. INTRODUCTION

Soil erosion is regarded as the major and most widespread kind of soil degradation and as such, affects significantly the sustainable agricultural land use (Oldeman 1994). Other problems caused by soil erosion include loss of soil nutrients, declining crop yields, reduction in soil productivity (Renard et al. 1997). Moreover, soil moved by erosion carries nutrients, pesticides and other harmful farm chemicals into rivers, streams, and ground water resources (Nyakatawa et al. 2001). Soil erosion is also a major environmental problem in China. The total area of soil

Succession of Potential Vegetation in Arid Area of Northwest China

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***Abstract*—Vegetation background research, especially the basic work of ecological environment construction in arid area of northwest China has become much more significantly gradually. Potential vegetation is the most stable and mature climax vegetation type which achieves the balance state finally without human interference, and it can also be used to rehabilitate and reconstruct of vegetation regionally. With the support of GIS technology, this paper analyzed the succession process of potential vegetation in arid area of northwest China based on the IOCSG model. The annual precipitation and above 0 ℃ annual cumulative temperature data in northwest China from 1961 to 2005 were provided by 119 and 115 meteorological stations respectively, The conclusion as follow: potential vegetation increased the complicated process of succession due to climate change in the study area. From the view of transformation characteristics and changes in quantity of potential vegetation types, the distribution area of potential vegetation shows there are three kinds of characteristics: reduced steady, increased steady and changed fluctuant. In the view of geographic distribution pattern change and the development direction of potential vegetation types, the main areas with significant succession include Turpan basin, northern Xilinguole plateau, Hulunbeier plateau, and Taipingling Region. The spatial change and succession direction of potential vegetation were different. With regard to the driving factors of potential vegetation succession, under conditions of climate changes, changes in hydrothermal conditions which affected the distribution of vegetation caused the changes of the decision relationship between climate and vegetation.**

Keywords- Potential vegetation; Succession; IOCSG; GIS

I. INTRODUCTION

The potential vegetation was derived from the concept of potential natural vegetation which was first proposed by Reinhold Tüxen in the long-term discussion process of succession of top-level issue in 1956 [1] [2]. It was of great concern by geographers, botanists, ecologists, and many other scientists, thus the study of potential vegetation has been developed rapidly. Here are some typical studies. Brzeziecki et al. developed the probability model of phytocoenosis including the climate, terrain, soil and other factors, which was used to simulate the geographical distribution of 71 kinds of forest communities in Swiss mountain integrating with the GIS technology [3]. Brown simulated four vegetation types in Glacier National Park in the United States and Canada, the simulation results were compared with Landsat TM-based vegetation classification [4]. Guisan et al. used the linear relationship between mean annual temperature and the mountain plant species to simulate the spatial distribution of alpine plant species in Valais region of Switzerland, and obtained high resolution distribution maps of species finally [5]. Dymond took advantage of soil moisture, temperature and solar radiation to simulate the spatial pattern of vegetation in Kananaskie River watershed in Canada [6]. Betts [7], Cramer and Bachelet et al. used DGVMs (Dynamic Global Vegetation Models) to simulate the global scale vegetation structure and distribution trends [8] [9]. Zhao et al. made some improvement in certain parameters and process of MAPSS model, and used the improved MAPSS model to simulate the potential vegetation types and distributions of leaf area index under the current climatic conditions in China [10]. Yang and Zhou made a comparison of simulated vegetation distribution in China produced by four popular climate-vegetation classification models [11]. Liu and Wu systematically summarized the research of potential vegetation and discussed the concept of potential natural vegetation, the temporal, spatial scale and research methods [12]. Zhao, Li and Wu made a comparison of climate-vegetation modeling in the Tibetan Plateau [13]. Zhao et al. studied the modeling of potential vegetation in Zulihe River watershed of

Sponsor: National Natural Science Foundation of China, No. 40961026, 30972135; The Quality Program of the National Featured Specialty, No. TS1Z249.

Volume calculation and analysis of the changes in moraine-dammed lakes in the north Himalaya: a case study of Longbasaba lake

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ABSTRACT. Glacial lake outburst flood hazards in the Himalayan region have received considerable attention in recent years. Accurate volume estimation for glacial lakes is important for calculating outburst flood peak discharge and simulating flood evolution. Longbasaba lake, a potentially dangerous moraine-dammed lake, is located on the north side of the Himalaya. Its depth was surveyed using the SyQwest Hydrobox^{TM} high-resolution echo sounder, and 6916 measurements were collected in September 2009. The maximum and average depths of the lake were 102 ± 2 and 48 ± 2 m, respectively. The morphology of the lake basin was modeled by constructing a triangulated irregular network, and the lake was found to have a storage capacity of 0.064 ± 0.002 km^3. Multi-source remote-sensing images from Landsat MSS, Landsat TM/ETM+ and Terra ASTER and a topographic map were digitized to delineate the outlines of the lake between 1977 and 2009. The results indicate that the length and area of the lake have increased during the past 32 years, with a drastic expansion occurring since 2000. Based on volume and area data of Longbasaba lake in different periods, we deduced an empirical equation of the lake volume–area relationship that can be used to calculate the storage capacity of similar moraine-dammed lakes in the Himalayan region.

INTRODUCTION

Glacial lakes are indicators of climate change because their expansion or contraction reflects variations of water balance and heat condition in mountains (Shi and Ren, 1990). In the Himalaya, a number of glacial lakes, of which moraine-dammed lakes are the most common type, have recently appeared and expanded in and around alpine glaciers (Che and others, 2004; Chen and others, 2005; Lu and others, 2005; Komori, 2008; Sharma and others, 2009; Gardelle and others, 2011). These expanding glacial lakes are often surrounded by steep slopes and contained by fragile moraines that are prone to failure. Devastating events (e.g. rockfalls, glacier calving and avalanches into the lake area) can create large waves and trigger flooding due to washout (Awal and others, 2010). In the past 50 years, >35 large glacial lake outburst floods (GLOFs) have taken place in the Himalayan region, many of which caused great damage not only to the local catchment but also to the surrounding lowlands far beyond the limits of the lake area (Xu and Feng, 1989; Clague and Evans, 2000; Carrivick, 2010; Shrestha and others, 2010). Meanwhile, small-scale GLOFs occur almost every year, usually going unnoticed because of the limited damage caused or because of their remote location (ICIMOD, 2007). GLOFs and related debris flows play a dominant role in mountain disasters in the Himalaya (e.g. Xu and Feng, 1989; Ding and Liu, 1992; Fujita and others, 2008; Bajracharya and Mool, 2009). Numerous studies have confirmed that temperature increase in the Himalayan region has been greater than in other areas at the same latitude (Zheng and others, 2002; Singh and Bengtsson, 2005; Li and others, 2011), and the rate of warming has been almost twice the rate of global warming since the 1950s (0.23 vs 0.13°C per decade) (Yang and others, 2006). During recent decades, glaciers in this region, as in many other regions worldwide, have experienced accelerated recession (Pu and others, 2004; Zhang and others, 2010). Given rapid warming and glacier retreat, it is anticipated that glacial lakes will continue to expand into the areas between receding glacier fronts and terminal moraines, and that GLOFs will become more frequent (Richardson and Reynolds, 2000; Haeberli and others, 2004; Yao and others, 2010). We therefore need improved monitoring of moraine-dammed lakes and a better understanding of GLOF mechanisms (Reynolds, 1998; He and others, 2002; Chen and others, 2007; Wang and Liu, 2007).

Accurate estimation of the storage capacity of moraine-dammed lakes is essential for predicting flood peak discharge, simulating flood evolution and establishing early warning systems (Bajracharya and others, 2007; Ng and others, 2007). As suggested by previous studies (Chen and others, 2008; Fujita and others, 2008), the volume of moraine-dammed lakes can be estimated from digital elevation models (DEMs) using reservoir capacity methods based on a grid, cross sections or contours. The volume of Telamukanli lake in the upper stream of Yarkant river, for example, was calculated using a cross-section method in a field study in 1987 (Shi and others, 1991). In addition, Evans (1986) and Huggel and others (2002) proposed an empirical relationship between glacial lake volume and area. For the moraine-dammed lakes in the Himalayan region, due to their harsh climate and remoteness, there is often a shortage of ground-based monitoring data, especially lake water depth (Wang and others, 2010). So far, in situ measurements of lake water depth have only been conducted at a few glacial lakes on the south side of the Himalaya (Bhargava, 1995; Yamada, 1998; Mool and others, 2001; Sakai and others, 2005). They have not yet been carried out on the north side, so there is

J. Resour. Ecol. 2015 6 (1) 012-020
DOI:10.5814/j.issn.1674-764x.2015.01.002
www.jorae.cn

Article

Quantitative Geography Analysis on Spatial Structure of A-grade Tourist Attractions in China

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Abstract: Tourist attraction is a very important carrier of tourism activities. A-grade tourist attraction is a national standard of comprehensive evaluation about tourist attractions quality and grade in China. In this paper, spatial structure of 2424 national A-grade tourist attractions are investigated by using GIS and quantitative analysis methods, such as nearest neighbor index (NNI), quadrat analysis, Gini coefficient and hot spot clustering. Spatial accessibility of all A-grade tourist attractions was calculated using cost weighted distance method and ArcGIS software. Service range of each tourist attraction at 4A grade and above in China was delimitated based on the cost allocation method. Results show that China's A-grade tourist attractions present aggregate distribution characteristics on the whole, and cultural attractions aggregate distribution is higher than of natural tourist attractions. Above-4A grade quality attractions aggregate distribution is lower than the Below-4A grade tourist attractions; cultural Above-4A grade are significantly greater than the cultural Below-4A grade tourist attractions. A-grade tourist attractions in China's eight districts are aggregate. The spatial distribution uniformity is low. Affected by the degree of economic development and tourism resources endowment, the service range of Above-4A grade attractions is big in West, small in East, big in North, and small in South. First-order hot spots areas were mainly concentrated in the east side of the line formed by Deqen-Alxa Left Banner. The second-order hot spot areas were composed of 11 regions, while the third-order hot spot areas include Beijing, Tianjin, Central Plains and the Yangtze River Delta.

Key words: spatial structure; spatial accessibility; tourist attractions; GIS; China

1 Introduction

Tourist attraction is an indispensable carrier of tourist activities, which has an important special status in the tourism activities (Guo *et al*. 2012). Spatial structure of tourist attractions refers to natural attractions and cultural attractions on the spatial correlation and combinations. It is the complex of node (spots), channel (communication) and domain (region) (Xie and Wu 2008), which is a hotspot of research on tourism spatial structure. Spatial structure of tourist attractions not only includes the combination of distribution pattern, grade and quantity, but also caused the spatial behavior of tourists directly, which has a profound impact on the tourist attractions' development speed, scale, efficiency, temporal-spatial arrangement, and the nature, extent, and development strategy of tourism regional spatial competition (Weaver 1998; Andreas 2004; Li and Wu 2012). Researches of tourism spatial structure began in the 1960's, mainly focusing on the spatial analysis and determination research of tourist source market, while on tourist spatial structure is less. Wilson (1967) proposed statistical theory based on tourist spatial distribution model. Miossec (1976) analyzed the evolution process of the destination tourism by using the spatial dynamic method. Dredge (1999) proposed three kinds of spatial structure model about tourism destinations. Sophie and Romain (2009) come to a conclusion that the accessibility have influence on tourism spatial structure and the economic structure. Chinese scholars have been more concerned about the spatial structure of tourist attractions that are mainly concentrated in: the accessibility and transportation of tourist attractions (Jin *et al*. 2009; Pan and Cong 2012), spatial distribution

Received: 2014-04-09 **Accepted:** 2014-11-13
Foundation: National Natural Science Foundation of China (No. 41061017, 41361040).
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Advanced Materials Research Vol. 216 (2011) pp 600-604
Online available since 2011/Mar/15 at www.scientific.net

doi:10.4028/www.scientific.net/AMR.216.600

Analysis on Spatial Pattern of Urban Heat Island and Impervious Surface Using Linear Spectral Mixture Analysis

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Keywords: Urban heat island; Linear spectral mixture analysis; impervious surface; Remote Sensing.

Abstract. Based on Landsat ETM+ data within the metropolitan area of Lanzhou, China, green vegetation(GV) and impervious surface was extracted by a constrained linear spectral mixture analysis (LSMA),together with single window algorithm to invert land surface temperature ,and the correlation analysis was then conducted to examine the relationship between urban heat island (UHI) effect and impervious surface. Four types of end members with high albedo, GV, soil and low albedo are selected to model complicated urban land cover, estimation accuracy is assessed using Root-Mean-Square (RMS)error and color aerial images, with the help of Mantel and Partial Mantel. Spatial relationship of land surface temperatures (LST), impervious surface and GV were analyzed. Results indicate that impervious surface distribution and GV can be derived from Landsat TM/ETM+ images with satisfactory precision. Impervious surface and GV were positively correlated with UHI, while LST has space dependence, it has high space dependence, and was higher correlated with impervious surface than GV.

Introduction

Urban heat island (UHI) effect is closely related to many important issues, such as urban climatology, environmental change, and human–environment interactions, affecting the quality of human life[1]. UHI and urbanization has obvious relationship, that is to say, UHI is remarkable according to the higher level of urbanization and building density, and the city impervious surface can be quantified to indicate UHI effectively[2]. Hot spot of urban heat island study is using thermal infrared remote sensing to examine the relationship between UHI spatial structure and urban impervious surface composition. Existing research focus on using Normalized Difference Vegetation Index (NDVI) to characterize the vegetation cover, thus explore the relationship with UHI. However, the NDVI and vegetation cover is not a simple linear relationship, which affected by many factors. And because of the objective existence of mixed pixel, the accuracy of research was greatly affected. Linear spectral mixture analysis (LSMA) is a physically based image processing technique, which supports repeatable and accurate extraction of quantitative sub-pixel [3]. The method has been used for UHI studies to extract vegetation coverage, impervious surface, and soil, and will be more meaningful and prospects [5]. In recent years, many scholars have carried out a large number of impervious surfaces on urban remote sensing research and exploration. Deriving accurate, quantitative measures from remote sensing imagery over urban areas remains a fundamental research challenge due to the great spectral and spatial variability of the materials that compose urban land cover [4].

Lanzhou city located in the valley, among the poor air flow and a large number of industrial emissions, resulting in poor air quality, urban heat island effect evident. In this paper, LSMA model was used to extract urban underlying surface. The spatial pattern of urban heat island was explored on the basis of land surface temperature retrieved from thermal infrared remote sensing image.

Measurement and analysis for urban hinterland area

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Abstract

Complex components for calculating the urban synthetical scale value are selected, with consideration to the following five specific aspects, i.e., population, economy, commerce, traffic and government capability, and the value is calculated by means of principal component analysis. Then, China is divided into 338828 grids, the scale of which is 5 km ×5 km, with the support of ArcGIS software. The field-strength of each grid influenced by cities at prefecture level or above in China can also be calculated. Meanwhile, each grid is allocated to exclusive city in the light of "maximal field-strength choosing" principle, and then, the hinterland area of 283 cities at prefecture level or above in China can be delimitated automatically. Finally, the coherence and difference between hinterland area and administrative division are studied by overlaying these areas with province boundaries. Results show that the difference of urban hinterland cities was obvious among the cities at prefecture level or above in China, and the concrete facts show that hinterland area of the western cities is larger than that of the eastern ones. The relationships between urban hinterlands are identified as four types: coexistence, inclusion, semi-inclusion and competition. The coincidence degree between urban hinterland areas and their administrative division is lower. The measurement results also indicate that application of GIS spatial analysis methods to delimitate urban hinterland is convenient, precise and feasible, which can be an alternative approach of urban economic region division and urban system planning.

Keywords:

urban hinterland; urban system; GIS; China

1 INTRODUCTION

City groups have mushroomed in China one after another along with the process of urbanization and regional integration, and various types of urban and regional planning are in the pipeline. Urban hinterland is the attractiveness and radiation of the city, which plays a leading role in socio-economic linkages of peri-urban areas (Wang and Zhao, 2000). Among them, promoting the coordinated development between cities and their hinterlands should be one of key steps. The study of urban hinterland has important practical significance. Formation of urban hinterland is the results of the balance between urban spatial interaction, forming a center-the hinterland of the structure, which provides raw materials and elements for the center, as well as impacted by the economic changes of center city. Determination of urban hinterland is fundamental significant for urban economic divisions, regional spatial analysis, adjustment of administrative divisions and hierarchical structure of urban system analysis.

Almost all of China's urban system planning carried out for all levels of administrative regions. Provincial and county-level areas are the same as natural and socio-economic areas generally, but we can not rule out the inconsistent part, which is prominent in prefecture-level cities (Wang and Xiang, 2006). Reasonable range of the county has not formulated specific criteria, when there is a great gap between planned sphere of the city and the actual attracted sphere of central cities, if we treated it as a complete system to plan, the scientific worth is of suspect. For the rational allocation of local resources, the administrative boundaries should be broken, according to the level of economic development to take advantage of intensive development model, in order to form regional development pattern of distinct functions and rational layout. It is necessary to divide urban hinterland of prefecture-level cities, and find the most reasonable model of intensive development.

According to the types of indicators and measurements, research methods can be divided into two categories: empirical method and model method (Berry and Lamb 1974). Due to the difficulty to get a variety of data and the lack of comprehensiveness, the model method is becoming the most important methods in the study of urban spheres of influence (Kong et al., 2004; Feng et al., 2006). In model method, ravity model is first applied to geography from the law of physics (Huff 1973; Liang 2008);Voronoi graph as a space partition method has been used gradually (Gold 1992); Field model uses the field strength to describe the changes from the centre to the edge, and to delimitate the urban spheres of influence (Wang and Chen 2004). There are also some defects in the model method: the lack of a comprehensive measure of the urban influence indicator; the objective urban classification which is the basis in gravity model; the complicated computation and weak interpretation of results in Voronoi graph; the ideal surface equally in all directions, etc.

At present, existing research only take population as standard to measure city's scale, using method of breaking point or weighted Voronoi diagram. Based on the above considerations, in support of GIS, this paper presented an improved field model method for the determination of urban spheres, taking urban hinterland of China's cities

International Journal of Biomathematics
Vol. 5, No. 3 (May 2012) 1260009 (23 pages)

DOI: 10.1142/S1793524512600091

World Scientific
www.worldscientific.com

A CLASSIFICATION INDICES-BASED MODEL FOR NET PRIMARY PRODUCTIVITY (NPP) AND POTENTIAL PRODUCTIVITY OF VEGETATION IN CHINA

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Received 23 January 2011
Accepted 17 November 2011
Published 19 April 2012

Net Primary Productivity (NPP) is an important parameter, which is closely connected with global climate change, the global carbon balance and cycle. The study of climate-vegetation interaction is the basis for research on the responses of terrestrial ecosystem

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J. Geogr. Sci. 2013, 23(2): 331-343
DOI: 10.1007/s11442-013-1013-y

Environmental suitability evaluation for human settlements in an arid inland river basin:
A case study of the Shiyang River Basin

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Abstract: The study employs slope, aspect, relief degree of land surface, land use, vegetation index, hydrology and climate, as evaluation indexes to set up the Human Settlements Environmental Index (HEI) model to evaluate the environmental suitability for human settlements in the Shiyang River Basin. By using GIS spatial analysis technology, such as spatial overlay analysis, buffer analysis and density analysis, the environmental suitability of the human settlement spatial situation and spatial pattern are established to analyze their spatial distribution. The results show that the index of suitability for human settlements in the Shiyang River Basin is between 17.13 and 84.32. In general, suitability for human settlements decreases from the southwest to the northeast. Seen from an area pattern, the suitable region is mainly distributed in the Minqin oasis, Wuwei oasis and Changning basin, which are about 1080.01 km^2 and account for 2.59% of the total area. Rather and comparatively suitable region is mainly distributed around the counties of Gulang, Yongchang and north of Tianzhu, which is about 1100.30 km^2. The common suitable region is mainly distributed outside the counties of Yongchang, Jinchuan and most parts of Minqin County, which are about 23328.04 km^2, accounting for 56.08% of the total area. The unsuitable region is mainly distributed upstream and to the north of the river, which is about 9937.60 km^2, accounting for 23.89% of the total area. Meanwhile, the least suitable region is distributed around the Qilian Mountains, which are covered by snow and cold desert and lie in the intersecting area between the Tengger Desert and Badain Jaran Desert. The total area is about 6154.05 km^2, accounting for 14.79% of the total area. Suitable regions for human habitation are mainly distributed around rivers in the form of ribbons and batches, while others are scattered. The distribution pattern is identical to the residential spatial pattern. In addition, the relationships between HEI and other factors have been analyzed. There is a clear logarithmic correlation between the residential environment and population, that is, the correlation coefficient between the evaluation value

Received: 2012-06-22 **Accepted:** 2012-08-06
Foundation: National Natural Science Foundation of China, No.41261104; No.40971078; National Social Science Foundation Youth Project of China, No.12CTJ001; Youth Fund Projects of Science and Technology from Gansu Province, No.1107RJYA077
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