Barrier Belt Division Based on RS and GIS in the Three Gorges Reservoir Area —— A Case of Wanzhou District

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Abstract

The Three Gorges Reservoir project is a famous project in the world for the profound and long-term effect. Barrier belts of the Three Gorges Reservoir were concerned by China and all worlds, for causing water loss and soil erosion, geologic hazards and environmental pollution. In this paper, taking Wanzhou district as study area, the division methods of barrier belts of The Gorges Reservoir Area were discussed. Applying Remote Sensing (RS) and Digital Elevation Model (DEM) data, the mutation lines of surface brightness temperature and surface humidity were obtained through analyzing the annual change from 1995 to 2008. Based on Geographic Information System (GIS) technology, ridge Line were extracted from DEM data. Under the principle of max scope, the ranges of barrier belts were divided. The results indicate that the influence distance of temperature and humidity change is only 35Km, for raise of the Three Gorges Reservoir. And the area of barrier belts is 2215 Km\textsuperscript{2}, 64.2\% of Wanzhou district. The results provide references for the Three Gorges Reservoir Area integrated studies.

Keywords: Barrier Belt Division, the Three Gorges Reservoir Area, RS, GIS, Wanzhou District

1. Introduction

Barrier belts of Three Gorges Reservoir Area are a typical and especial ecological fragile zone [1]. It is unstable for being impacted by water level change of Three Gorges Reservoir. In this ecological fragile zone, human activities have great impaction on the ecological environment [2]. And it may cause a

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catastrophic consequence to the Three Gorges Reservoir. So the unreasonable utilization modes must be corrected in prior period of full operation of Three Gorges Reservoir. In the barrier belt, there are seven mega cities, two big cities and hundreds towns. Large numbers of people and industries distribute in the belt. The land utilization modes have great impaction on water quality, sediment deposition, reservoir bank stability, and so on.

From the year of 2003, the Three Gorges Reservoir began to impound water. But in the eight years, there is few studies focus on the barrier belt. At the present, there are more than eighty thousand reservoirs in china. The area of barrier belt is great. The barrier belt of Three Gorges Reservoir is typical in the significance, particularity and typicality [3].

In this paper, it took Wanzhou district of Chongqing as studied area. The data, including RS image in the years of 1995, 2000 and 2008, and the DEM, were applied to analyze the change of temperature and humidity. Combing the extraction of ridge line from DEM, the principle of max scope was applied to divide the barrier belts ranges of the Three Gorges Reservoir Area in Wanzhou district. The results provide references for the integrated studies of the Three Gorges Reservoir Area.

2. Study Area

Wanzhou District is located at the east edge of Sichuan Basin and northeast edge of Chongqing Municipality, from 107° 55 ′ 22″E to 108° 53 ′ 25″E and from 30° 24 ′ 25″N to 31° 14 ′ 58″N. It borders Yuyang in the east, Shizhu and Lichuan Hubei in the south, Zhongxian County and Liangping in the west, and Kaijiang and Kaixian County in the north. It covers a length of 97.25 km from east to west and a length of 67.25 km from south to north as well as an area of 3,457 km². Hills and mountains are main landforms in the area, with the highest point (1,762m above sea level) at Shaping Peak of Puzi Township and the lowest point (106m above sea level) at Huangbai Township on the banks of The Yangtse River. Low mountains and hills as well as mid-low mountains and flat land account for 1/4 of the area respectively. A very few flat dams and platform scatters there and there. A lot of rivers and streams spread all over the area in a tree-like form, featured by large depth, great fall, different height, and all of which belong to The Yangtse River system. In the area, outcropping strata consists of a large area of Jurassic stratum, followed by Triassic stratum. The tectonic line belongs to Wuling mountain fold zone on No. 3 huge uplifted zone of Neocathaysian system. The west edge of Wuling mountain fold zone borders Daba mountain arc fold zone, extends along east-north direction out of the area, and disappears at west-north side of Qiyao mountain anticline. Thus, the Wanxian arc tectonic line stretching toward the northwest is formed.

![Figure 1: Range of the studied area and DEM](image)
2. Data Source and Methods

2.1 Data Preprocessing

This study applied the Landsat images in the year of 1988, 2000, and 2008. All images were projected in ALBERS, which center median was 105° east, and double standard parallels were 25° and 47° north. The resolution of images was 30m. And the sixth band of TM was applied mainly [4].

The preprocessing of remote sensing images includes image transformation, radiometric correction, geometric correction, and so on. Radiometric correction can reduce distortion of image radio value. And geometric correction can reduce the correction, which caused by the change of satellite attitude, speed, altitude. Image transformation can improve the definition. To further application, all origin remote sensing images must be preprocessed.

All images were processed by radiometric eradiation, geometric correction and transformation by the software of ENVI.

2.2 Surface Brightness Temperature Calculation

Because of high resolution, TM image of Landsat were applied in various field. The sixth band of TM (TM6) can apply to analysis the difference of thermal radiation in various areas.

Brightness temperature is a relative value, that intensity of thermal radiation can be observed by satellite. Because of being influenced by atmosphere and ground surface, the brightness temperature value must be preprocessed by radiometric correction. After being radiometric corrected, brightness temperature value can be calculated from digital number (DN) value (formula 1, formula 2). Generally, DN is high, and brightness temperature value is high [5].

$$L_{(\lambda)} = L_{\min(\lambda)} + (L_{\max(\lambda)} - L_{\min(\lambda)}) \frac{Q_{dn}}{Q_{max}}$$ (1)

Where: $L_{(\lambda)}$ is radiometric value which received by TM sensor. $Q_{max}$ is max value of DN, and it is 255 generally. $Q_{dn}$ is DN value of each cell in TM data. $L_{\min(\lambda)}$ and $L_{\max(\lambda)}$ are the min value and max value of radiometric value which received by TM sensor.

$$T_{6} = K_{2}/\ln(1 + K_{1}/L_{(\lambda)})$$ (2)

Where: $T_{6}$ is brightness temperature value of each cell in TM data. $K_{1}$ and $K_{2}$ are presupposition constant, which $K_{1}$ is 60.776 mWcm-2sr-1um-1, and $K_{2}$ is 1260.56K.

2.3 Methods of Surface Humidity Calculation

Applying the band process functions of ENVI software, different band of TM images were analyzed and surface humidity were calculated.

2.4 Methods of Ridge Line Extraction

Applying hydrological analysis functions of ARCGIS 9.2 software, ridge line can be obtained base on digital elevation model (DEM).

Methods of Barrier Belt Division
Lots of factors impact on the three gorges reservoirs area. According to the results of reservoir water filling, the changes of temperature and humidity are most outstanding. So, the isohumes and isotherms are changing in the process of reservoir water filling.

Temperature mutation lines can be got from brightness temperature maps of various years. And humidity mutation lines can be obtained form humidity maps of various years. After comparing temperature mutation line, humidity mutation line and ridge line, the line most far away from reservoir area can be taken as the boundaries of barrier belt.

3. Results

3.1 Brightness Temperature Mutation of Wanzhou District

Applying the calculation of mono-window algorithm, the data of surface brightness temperature in the year of 1995, 2000 and 2008 were obtained. After be standardized and overlaid, the mutation lines of surface brightness temperature were calculated. And the change area of surface brightness temperature in the process of impounded level rise (figure 2).

The distribution map in the year of 1995, 2000 and 2008, were compared. And the mutation lines of surface brightness temperature in Wanzhou district were acquired. Statistical results indicated that the area of surface brightness temperature change obvious was 1339.97Km2 in Wanzhou district since the operation of the Three Gorges Reservoirs. It is 38.8% of Wanzhou district total area. It can found from figure 2 that the surface brightness temperature in Wanzhou district was obvious impacted by the rising of impounding level in the Three Gorges Reservoir. The max influence distance is 30Km, which indicates that the influence of surface brightness temperature impacted by the Three Gorges Reservoir water level rising was limited. In the influence scope, the main direction was expanded form water level line to banks. At the same time, the expansion directions and scopes were impacted by the distribution of the terrain. The expansion modes were difference in different topographic position. The change of surface brightness temperature in low area was obvious. And companying with the raise of elevation, the influence of the water level raise impacting on surface brightness temperature reduced rapidly.

3.2 Humidity Mutation of Wanzhou District
Applying the software of ENVI, three bands of LANDSAT TM image, including second, third and fourth, were applied to calculate the value of surface humidity. And then, the values were standardized. The surface humidity grids were calculated in overlaying model in the three years, including 1995, 2000 and 2008. And mutation lines were abstracted from the calculated grids (figure 3).

It can be found from figure 3 that water level of the Three Gorges Reservoir Area influence on the surface humidity in the area obviously. The max distance which been influenced was 30Km from the reservoir area. After been calculated by statistical software, the area which the values of surface humidity change obviously was 1511.7 Km², and 43.8% in Wanzhou total area. It indicates that the degree which of the rise of Three Gorges Reservoir Area water level influence on surface humidity is not very strong.

In the influence scope, the direction of influence was spreading from water level line to band mainly. Because of the influence of topographic, the spreading direction and the spreading scope were different. The lowland area forms change obvious area. And along with the rise of elevation, the influence became weaker.

3.3 Ridge Line Distributions Changes of Wanzhou Districts

Through combining methods of plan curvature and slope shape, the map of ridge line distribution was obtained [6]. To keep same cell size with surface humidity and surface brightness temperature, the grid size and the statistical unit were adjusted [7]. (Figure 4)

It can be found from ridge line distribution map that there were two parallel ridge lines on the both sides of the three Gorges Reservoir Area in Wanzhou district, the area of region enclosed by the two ridge line is 2179.7 Km², accounting for 63.2% of total area in Wanzhou district. The highest elevation on the two ridge line is more than 1700m. And the height difference is more than 1500m in the region. The two ridges in Wanzhou district are barrier that make the change of humidity and temperature weaker.

![Figure 3](image-url)
3.4 Barrier Belt Division of Wanzhou Districts

Applying the software of ArcGis, the mutations of surface humidity and temperature were overlaid. In the principle of max value, the barrier scopes of the Three Gorges Reservoir were divided.

Statistics data indicated that the barrier scopes in Wanzhou district were main located in the area, which 35km away from the river bank. The area is 2215 Km², occupying 64.2% of total area. It can be found from figure 5 that the scope form by ridges is bigger than the scopes form by the humidity and the temperature. Excluding influence of the two ridges impacting on the change of humidity and temperature, the other lofty terrains have obvious influence too. The nicks among loft terrains form important channels for the change of humidity and temperature.

In the barrier, the increase of water level in the Three Gorges Reservoir has obvious impaction on the change of humidity and temperature. And at the same time, the unreasonable human activity has menace to the safety of the reservoir directly.
4. Conclusion

Based on the above analysis, following conclusion has been drawn:

Since the impoundment of the Three Gorges Reservoir, the increase of impounding level has obvious impact on the surface humidity and temperature along the banks. The influence direction was from the bank to ridge line. Because of the influence of topography, the change scope and direction of the surface humidity and temperature were different obviously.

Overlaying the ridge lines, mutation lines of surface temperature and humidity, the scope of barrier belts were made clear. The area of barrier belts is 2215 Km², occupying 64.2% of total area.

Only applying three TM image, the precision and veracity of research results need further study. At same time, the further studies, including the change of the eco-environment, land use and land cover change, environment evaluation in the Three Gorges Reservoir area need to go on study.

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Reference


