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Research on River Networks Extraction Based on RS and GIS

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Abstract. In view of the arid and semi-arid situation in most areas of Longchuan river basin, it is helpful to study the hydrological characteristics of the watershed to alleviate the drought situation in the region. Through the GDEM image provided by ASTER sensor carried by Terra satellite, the DEM data is preprocessed in GIS, the automatic extraction of river network, channel classification and sub−basin division are realized. The method of calculating the inflection point of the curve of the confluence accumulation and the density of the river network is used to determine the threshold value, and finally the river network water system which is consistent with the actual river is extracted.

1. Introduction

The combination of GIS and geo hydrology has established a widely applicable river network feature model [1-2], which can comprehensively reflect regional hydrological characteristics, such as watershed geomorphology [3-4]. Extraction of river network can keep the soil in the study area, the ecological environment and other follow-up studies provide good data support. Because flood and debris flow are often occurred in Longchuan river basin, it is of great value to study the characteristics of water system in the study area for the prevention of geological disasters and the comprehensive management of ecological environment.

2. The study area

Longchuan river basin is located in the transitional zone of Yungui Plateau and Hengduan Mountains in southwest China. The geographical coordinates are between 101 ° 04 ' 53 " ~ 102 ° 04 ' 09 " east longitudes and 25 ° 04 ' 03 " ~ 26 ° 14 ' 46 " in the north latitude, the maximum vertical distance between the north and the south is 130.60 km, the maximum horizontal distance is about 99.09 km.

The length of the main river is about 97 km and the area about 7252 km square. The elevation of the basin is 901 ~ 3115m, with an average elevation of 1997m. The relative drop between the highest elevation and the estuary is about 2000 m, and the average slope of the riverbed is 4.8 ‰.

3. Materials and methods

3.1. Materials

ASTER GDEM (Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Digital Elevation Model) is a NASA and METI jointly launched a new generation, according to NASA's earth observation satellite Terra detailed view of earth electronic terrain data produced. Its data coverage reached the land surface 99% of the earth of all land area contains 83 degrees north latitude to 83 degrees south latitude between the global spatial resolution of 30m. In this paper, the DEM image of the Longchuan river valley in Chuxiong Prefecture, Yunnan Province, China is selected as the base data (Figure 2).

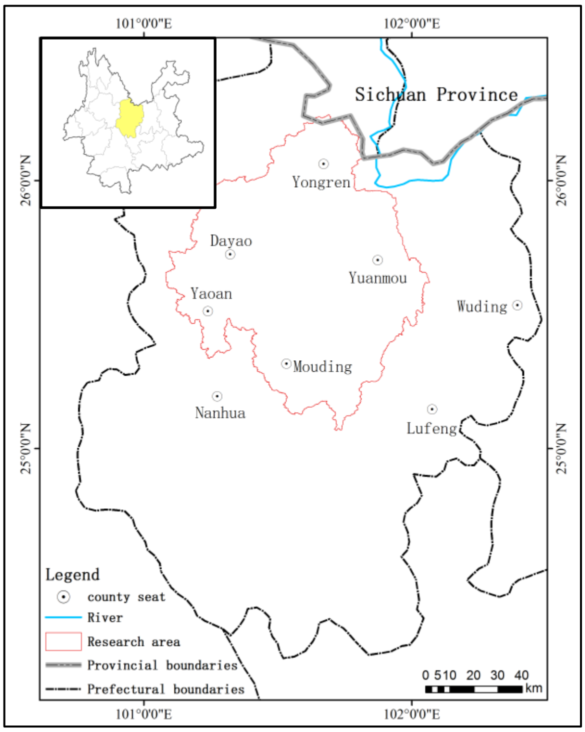

Figure 1. Geographic location of the study area

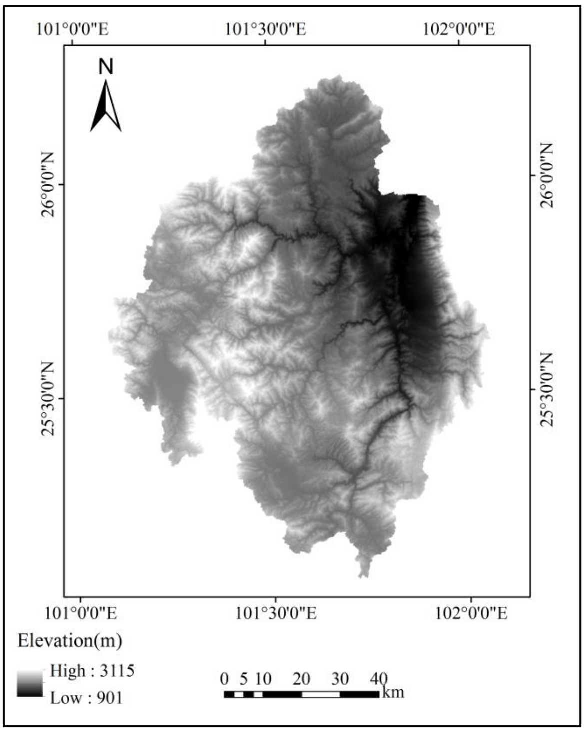

Figure 2. DEM data

3.2. Methods

On the basis of DEM data, the water system is extracted by GIS spatial analysis method to extract the hydrological characteristics of the study area, and a great deal of work has been carried out in this area [5-6]. The ArcGIS hydrological analysis module is used to automatically extract the river network under different drainage area threshold and to calculate the river network density under each threshold value. The curve of fitting the density and threshold of river network is tangent to find the inflection point to judge the optimal drainage area threshold, and the comparison between the river network and the actual river system is basically the same. The specific processes for automatic extraction of river network are as follows:

- Data preprocessing: fill in the depressions existing in the DEM [7].
- Flow direction calculation: D8 algorithm is used to determine the flow direction of each grid and form the flow chart [8].
- Confluence cumulant statistics: the accumulation of confluence is calculated on the basis of determining the flow direction grid.
- River network grid generation: on the basis of the accumulation of confluence, a river grid network is formed with a given threshold.
- River network generation: the water system map of the river network is generated by the flow grid and the river network grid.
- Channel classification: according to the flow direction grid and river network grid to form a river network hierarchical grid [9].

- Sub-basin Division: the location of the outlet of a small basin through the direction of water flow, and the grid of all upstream effluent points flowing through the outlet is a sub-basin.

4. Extraction of River Network based on GIS

At present, the main land surface runoff model is used to extract the river network. The calculation process takes the direction of the flow and the accumulation of the confluence as the basic premise, and sets a reasonable critical value (drainage area threshold) to extract the river network. In the method of determining the drainage area threshold in the former, the " inflection point method " is adopted, that is, the river network generated under different thresholds is analyzed. When the value of drainage area threshold is different, the difference of the extracted river network is greater. The smaller the confluence accumulation is, the denser the river channel is, the greater the river network density is, and the larger the accumulation amount is, the sparser the channel is and the smaller the river network density is.

The confluence cumulants selected 28 values in the range of 0.01×10^5 to 1.0×10^5, and the river network density under each threshold was counted one by one. The river network density under different thresholds was simulated to synthesize a curve (Figure 3). With the increasing of the accumulation value of the confluence, the density of the river network and the number of the sub-basin show a general downward trend, and the decreasing trend changes from the first rapid reduction to the gradual and slow decrease. When the accumulation of confluence increases from 0.01×10^5 to 0.10×10^5, the curve of relation between the density of river network and the accumulation of confluence decreases sharply. The density of the river network decreased from 0.8646 km/km square to 0.2755 km/km square, when the accumulation of the confluence increased from 0.10×10^5 to 1.00×10^5, the density of the river network was reduced to 0.0932 km/km square.

Based on the fitting curve between the density of the river network and the accumulation of the confluence, the inflection point of the curve is obtained, that is, when the change rate of the accumulation of the confluence is equal to the change rate of the density of the river network, the corresponding threshold is the best threshold.

$$y = -x + \varepsilon \tag{1}$$

y, the drainage density; x, the flow accumulation; ε ,Nodal increment.

General equation:

$$\begin{cases} y = -x + \varepsilon \\ y = 0.0909x^{-0.484} \end{cases} \tag{2}$$

A point tangent to a power function is an inflection point. In mathematics, the inflexion is defined as the stable point, and the change rate of the initial confluence cumulant is smaller than that of the density of the river network, and the inflection point appears when the rate of change is equal. After that, the rate of change of the accumulation of the confluence is greater than that of the density of the river network. The calculated inflection point is the point where the change of the density of the river network reaches a stable point with the change of the accumulation of the confluence, and the corresponding threshold value is the reasonable drainage area threshold of the river basin. Finally, it is determined that the optimal catchment area is 0.12186×10^5, that is, the optimal drainage area threshold is 1.10 km square, a river network is generated at this threshold. The resulting channel classification and sub-basin division results are as follows.

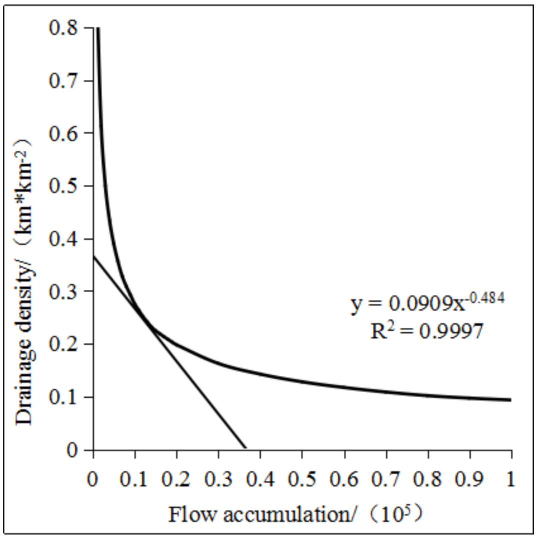

Figure 3. Fitting a curve

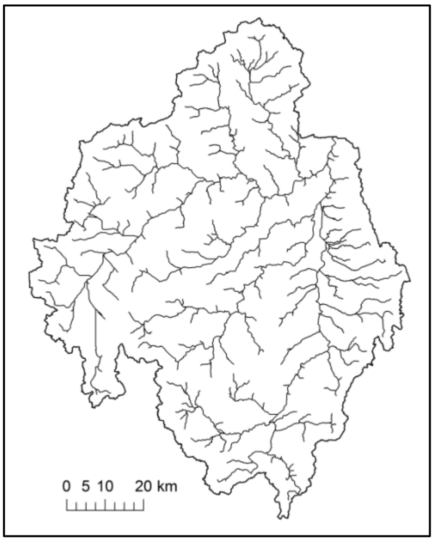

Figure 4. River network

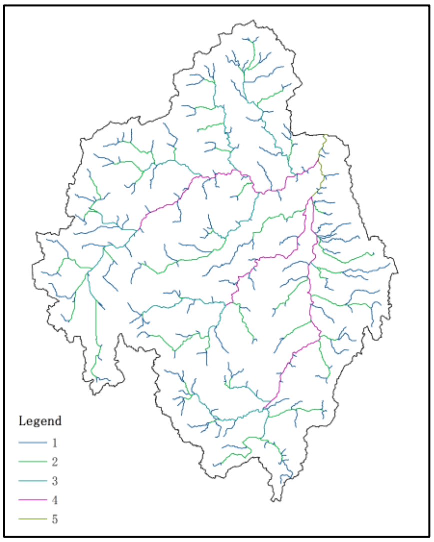

Figure 5. Channel classification

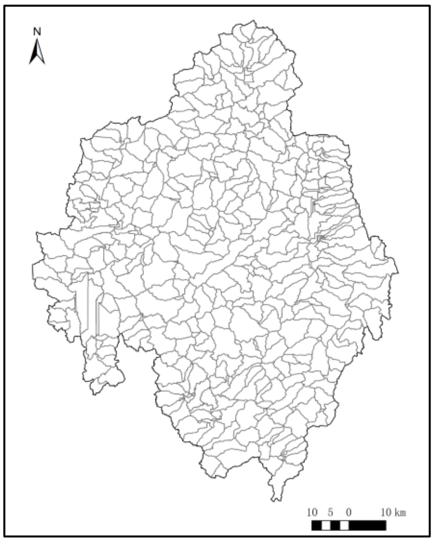

Figure 6. Sub-basin

5. Conclusion

The ASTER GDEM data were preprocessed by the sensor to receive satellite information, and the river network was automatically extracted on the platform of GIS. The best threshold is determined by making the tangent curve of the confluence cumulant and the density fitting curve of the river network, and the extracted river network is basically consistent with the actual natural river. Access to remote sensing images combined with topography, water features, timeliness and universality, reduces the workload of field reconnaissance, provides data support for ecological comprehensive watershed management.

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