Extraction and Analysis of Slope, Slope Length, and LS for National Soil Erosion Inventory in China

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Abstract—In order to meet the demand of topographic parameters for national soil erosion inventory and mapping, hydrologically correct DEMs (Hc-DEMs in short) with 25m resolution for China have been generated with more than 21000 map sheets of 1:50,000 topographic maps (using contours, spot heights, and part of the streams), primary topographic parameters, including slope, slope length (distributed watershed slope length), and aspect, have been extracted, then a compound parameter, slope length factor (LS), has been calculated based on the fundamental principles of soil erosion and geomorphometry. All the parameters have been analysis, and the results showed that: (1) DEMs representing the terrain shape accurately and correctly, with some preprocessing, and following certain procedures,are base and prerequisite for the extracting of slope, distributed watershed slope length, aspect and calculating of LS (figure 1). (2) Hc-DEMs with 25m resolution generated in this project represent the topographical features of the country, and the parameters, including slope degree, distributed watershed slope length, and aspect, are consistent with general principles and regular understanding of erosional geomorphology (figure 2). (3) It is possible for all the parameters to be extracted and calculated based on the DEM with standard quadrangle DEM datasets (1.5º×1.0º of 1:250,000). But the DEM must be extended the boundary out for some distance for extracting of distributed watershed slope length; the distances at least are 3.8 km and 2.8 km for gentle and steep terrain area respectively. (4) Some local scale characteristics and also large scale differentiation laws for themes of slope and distributed watershed slope length can be identified in China. The slope degree is steeper in the mountainous area, hilly areas (especially in loess hill of northwestern China, red earth hills of southern China), and transitional areas among three terrain ladders. The distributed watershed slope length is longer in gentle hills, mountains in Hengduan mountain area of southwest China, and centre area of Qinghai-Tibet Plateau (figure 3 and figure 4, and table 1). (5) Generally speaking, the calculation result of LS factor is influenced by the slope and distributed watershed slope length synchronously. But it is much more influenced by the slope degree. As result, LS is basically consistent with the slope, and similar to slope, in the geo-spatial pattern and distribution in China (figure 5, figure 6). This paper also proposes some problems to be further researched, including: resolution of DEMs of representative areas, analysis and assessment of the quality of the slope and distributed watershed slope length datasets, scaling effects of slope, distributed watershed slope length and LS factor, analysis of factors influencing on extraction and calculation of LS factor, applicability of the parameters in soil erosion assessment and mapping, methodologies for making thematic maps for slope, distributed watershed slope length, aspect and LS factor for Chin at small map scale (1:4 million).

Key words—soil erosion; slope degree; slope length; LS factor; geomorphometry

1 Introduction

The fourth national soil erosion survey is now onging. The Chinese Soil Loess Equation (CSLE)[1] is used in the water erosion assessment, in which the LS factor is needed. There are series of researches on LS factor [2-5]。However, there is few researches on LS factor in large extent (larger watershed or national scale) and with relatively high resolution source data. In this paper, the authors talked about some questions in the extraction and analysis on LS factor in Chinese soil erosion survey.

2 Method

2.1 Base data

In this paper the base data included DEMs all over China which was built based on 1:50000 topographic maps. And the layers of contours, spot heiths, and streams were used in the DEM generations. There were more than 22000 map-sheets in total. And the topographic maps had been checked before building DEMs.

2.2 Calculation of terrain parameters

Slope degree and aspect were calculated in ARCGIS9.3 using slope and aspect functions. Slope length was calculated based on runoff cumulative method proposed by Hickey[7] and the software developed by the authors[8-9]. The LS factor was calculated based on functions proposed by Liu baoyuan[10-12].

2.3 Mapping and analysis

Mapping about slope degree, slope length and LS factor were designed and mapped based on 25m resolution data talked above.

3 RESULTS AND ANALYSIS

3.1 Presentation of erode terrain surface

DEMs were built using the software ANUDEM[13-14] in this paper. The technical route is as Fig.1. DEMs built using this method are able to present varied types of terrain in China scientifically and accurately. The DEMs presentation of terrain is accordance with field survey and reported by references[15] (Fig.2).

(Fig.1 and Fig.2 near here)

3.2 Micro characteristics of terrain parameters

The microcosmic characteristics of slope degree, slope length and LS factor were analyzed and the result shows that: Slope degree is smaller in undulated hills in the northeast of China, and greater in hilly red soil region of south-east of China and purple soil hilly area of Sichuan Basin. In Loess hilly areas, it's steeper below the gully edge line and flatter in the upward areas of the line (Fig.3 and Tab.1).

(Fig.3 and Tab.1 near here)

Slope length increased from local high ppoint downward along flow path. In the view of small watershed, slope length increased from waterline downward, which is accordance with the extraction principle of slope length (Fig.4 and Tab.1).

(Fig.4 near here)

The surface of LS factor is influenced both by slope degree and slope length, but the influence of slope degree is greater than slope length (Fig.5).

3.3 Macro characteristics of terrain parameters

There was obvious macro characteristics of terrain parameters (including slope degree, slope length and LS factor), which were shown by small scale maps of terrain parameters (Fig.6).

(Fig.5 and Fig.6 near here)

The steep areas in China distribute in Hengduan Mountains, Qinling Mountains, mountains in east of Sichuan Province, Northern Rock Mountains, Liaodong Peninsula, Hilly Red Soil Region of South-east of China and Loess Hilly areas. These areas are mainly located in the transition region of the Three Gradient Terrain of China.

The slope length was shown to be longer in the areas following: the undulated hills in the northeast of China, the Southwest Mountainous region (Hengduan Mountains) and the hinterland of the Qinghai-Tibet Plateau. In most of the hilly areas, such as Loess hilly areas, north hilly areas of China, purple soil hilly area of Sichuan Basin and hilly red soil region of south-east of China, the slope length is shorter.

In the areas of Southwest Mountains, hilly red soil region, Loess hilly areas and northeast of China, LS factor was relatively large. There were two kinds of reason for the large LS factor value, one is steep slope (mainly in hilly areas), and the other one is steep slope and long slope length (for example in Southwest Mountainous region).

4 CONCLUSION AND DISCUSSION

We can conclude as follows: 1) a certain processing route should be followed and pre-processing should be taken in the processes of Hydrologically correct DEMs building. 2) Hc-DEM with resolution of 25m could be used to present terrain characteristics all over China and in typical terrain areas. 3) There were both macro and micro characteristics in slope degree and slope length surface. At the national scale, slopes are steepy in the transition region of the Three Gradient Terrain of China and in hilly areas. And slope length was large in gentle hilly areas, Southwest Mountainous region and the hinterland of the Qinghai-Tibet Plateau. 4) Generally speaking, LS factor was influenced both by slope degree and slope length, but the influence of slope degree was greater, thus the national spatial pattern of LS factor was basically accordance with slope degree.

5 DISCUSSION

Some questions still needs to be answered, such as, what is the appropriate resolution in different terrain areas, some questions about the data quality assessment of slope degree and slope length, influence of scaling effect of slope degree and slope length on LS factor, slope degree and slope length maps at small scales and influence factors of LS calculation.

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Figures and Tables

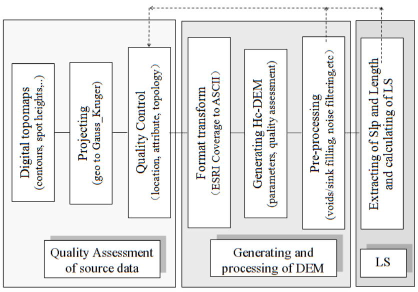


Fig.1 workflow of LS extraction

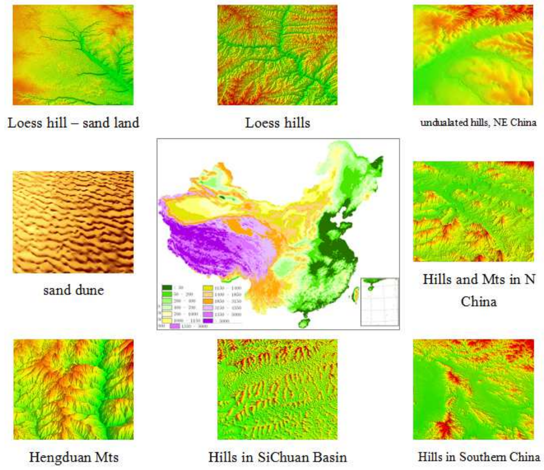


Fig.2 DEMs of China and representive areas

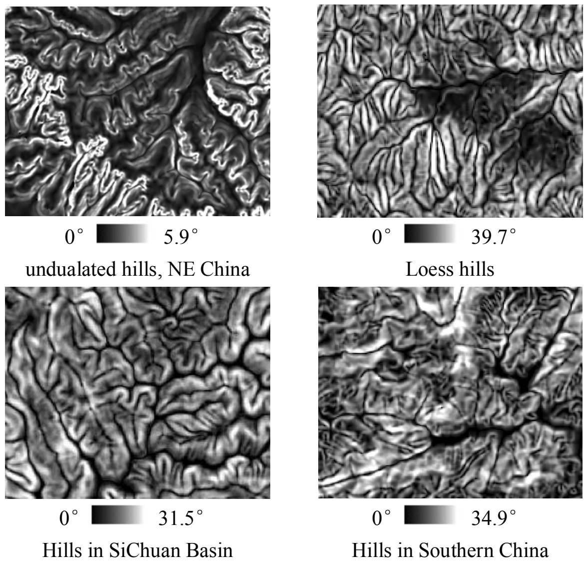
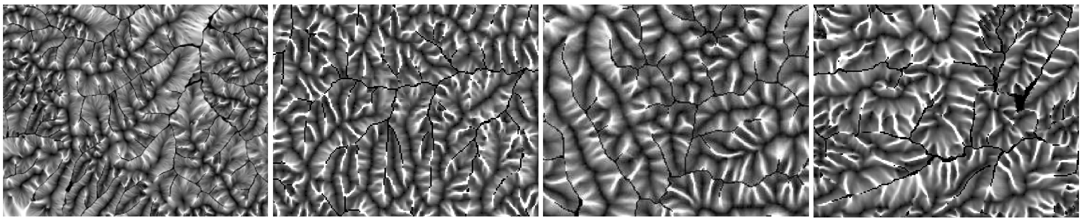


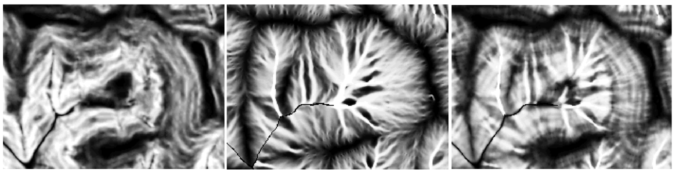
Fig. 3 microscopic characteristics of slope in main erosion area of China



12.5m 874.2m 12.5m 328m 12.5m 449.2m 12.5m 447.4m

undualated hills, NE China Loess hills Hills in SiChuan Basin Hills in Southern China

Fig. 4 microscopic characteristics of distributed slope length in main erosion area of China



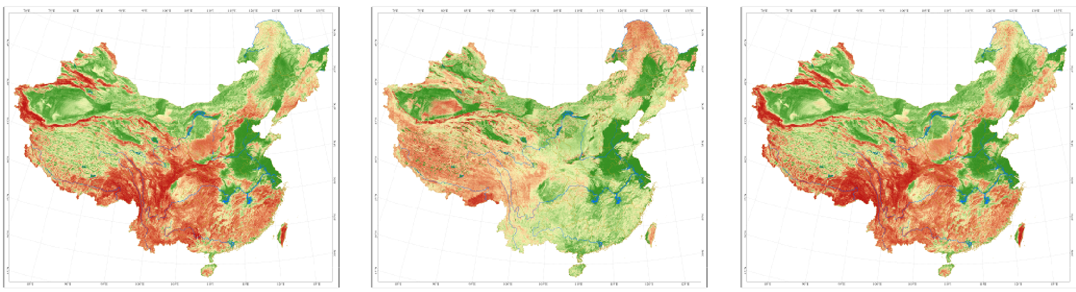
0° 56.2° 1.25m 157.1m 0 31.5

slope Slope length LS

Fig. 5 spatial pattern of slope, slope length, and LS

Tab. 1 statistics of slope, slope length and LS for main erosion area of China

sites	mean	medium	max	std	mean	medium	max	std	mean	medium	max	std
	slope/degree				slope length/m				LS			
undualated hills	2.02	1.7	5.9	1.26	208.18	150	874.2	191.31	1.17	0.9	4.2	0.98
Hills in Sichuan	18.53	19.2	31.5	6.74	123.12	100	449.2	98.20	13.69	13.6	32.6	7.86
Hill in South	18.46	18.9	34.9	7.69	103.72	70.7	447.4	94.02	12.51	11.3	34.2	8.32
Loess hills	21.46	22	39.7	9.14	82.84	67.6	328	67.90	13.87	13.1	35.1	8.60



a. slope (0.0° 56°) b. slope length(12.5m 1000m) c. LS(0 50)

Fig. 6 Maps of topographic parameters, China