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Research on FBM characters of watershed vegetation feature based on NDVI

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ABSTRACT

It is an important research direction that quantifies and expresses the spatial distribution complexity of vegetation cover at the time of studying the relationship between vegetation and matter migration on the watershed. In this paper, fractal dimensions of FBM for watershed vegetation cover are calculated on the basis of GIS, FBM theory and spatial distribution of NDVI. The results showed that the spatial distribution of vegetation on the watershed possesses a strong self-similarity and can be described by FBM theory. Fractal dimensions of FBM for watershed vegetation cover is ranging from 2.5 to 3. When it is getting close to 2.5 the spatial distribution of vegetation is more complicated.. There are no direct relationships between fractal dimension of FBM for watershed vegetation cover and the averaged NDVI of watershed or coefficient variation of NDVI for pixel. There exists nagtive relationships between fractal dimension of FBM for watershed vegetation cover and the numbers of different NDVI per square kilometer. Fractal dimension of FBM for watershed vegetation cover increases with an rise of watershed area and is toward quasi-steady state when watershed area reaches to a given scale. Compared with the traditional quantified parameter of vegetation cover, fractal dimension of FBM takes advantage of conquering the effect of singular value of NDVE and being used widely.

KEYWORDS

Vegetation; Fractal dimension; Watershed; Normalized difference vegetation index; Vegetation cover; Fractional Brownian motion.

INTRODUCTION

Vegetation, as an important part of terrestrial ecosystems, is an important factor of affecting process. Selecting the appropriate indicators to accurately quantify the role of vegetation and the expression of surficial materials in the migration process is an important issue on the transfer relationship between vegetation and surface mass.. In the aspect of quantifying features in the vegetation cover and characterization, there are a lot of researches (Barbosa, Huete, and Baethgen, 2006; Cammeraat and Imeson, 1999; Douglas, 1967) from the initial vegetation cover, leaf area index to a large number of remote sensing images based on vegetation indices (such as PVI, SAVI, MSAVI, TSAVI, ARVI, GEMI, AVI, NDVI, *etc.*). But the normalized difference vegetation index NDVI calculation is simple and easy access to getting calculation parameters and monitoring a wide range and can well reflects the extent of lush vegetation, which has a relatively good relationship with biomass and leaf area index. And it also makes the indicator been used widely to characterize vegetation conditions (Asrar, Kanemasu, and Jackson, 1985; Jiang *et al.*, 2003; Yan *et al.*, 2012). However, the number of indicators of vegetation cover, at different scales, mostly are through weighted mean to characterize the condition of vegetation cover, without considering the spatial distribution of vegetation and characterizing the features of vegetation cover fully(Liu and Yao, 2010; Surfleet, Skaugset, and McDonnell, 2010; Zhang, Yang, and Zepp, 2004). For patches in the landscape ecology and landscape scale, the researchers use a measure of landscape heterogeneity index (such as single plaque isolation, heterogeneity index and the dispersion of multiple plaques, *etc.*) to express vegetation spatial distribution and complexity. Also, what related to statistical methods is used to research the spatial distribution of vegetation covered, such as spatial autocorrelation analysis, semivariogram, trend surface analysis, *etc.* (Carlson and Ripley, 1997; Cuo *et al.*, 2008; Tian and Min, 1998; Wang, Liu, and Huete, 2003). These methods analyze the overall change in spatial distribution of vegetation cover, but they do not use simple parameters to quantify and characterize the complexity of the spatial distribution of vegetation covered enough.

Currently, the using of fractal theory spatial distribution of vegetation not goes deep into pixel scale, but the research, based on the scale of $ vegetation cover as the number of characteristic parameters to a comprehensive expression of vegetation cover or regional scale spatial distribution on the complexity of the basin, is also rarely reported. Fractal theory of Brownian motion, proposed by Mandelbrot, *etc.*, is a mathematical model that is used to describe the nature of random fractals. There are existing applications in geomorphology, whereas the theory describing the vegetation coverage has not yet been reported. This paper takes geographic information system (GIS)as platform, will handle the special distribution picture of pixel NDVI values by digital elevation (DEM) data structure, form watershed pixel scale raster digital vegetation model DVM (Digital vegetation Model); Pixel-based NDVI values, combing with fractional Brownian motion (Fractional Brownian Motion, FBM) theory, and will develop related GIS algorithm and calculate fractional Brownian motion fractal dimension based on pixel-based watershed vegetation yuan NDVI coverage so as to characterize the complexity of the distribution of the vegetation cover watershed, to analyze the different scales of the basin changes, and to provide a more comprehensive approach to integrated watershed vegetation cover spatial distribution characteristics quantified expression.

BASIC PRINCIPLE

Digital vegetation model

According to the equation of NDVI (Wang *et al.*, 2010; Xu *et al.,* 2014; Zheng, 2006), and the basis of space remote sensing NDVI values extracted distribution picture, the basin surface spatial distribution of NDVI values can be understood as: it is composed of a large number of remote sensing image pixel size small cube with sides of length unit, NDVI value is stored in the attribute table for each small cube unit "VALUE" field in the form of attribute, which is similar to the digital elevation (DEM) data structure and establishes vegetation digital model (DVM) based on NDVI. The characteristics of degree of surface density spatial distribution of vegetation basin, aggregation state, distribution patterns can be composed of these small cubes units arrayed in different combinations in the plane. The schematic of the digital vegetation model diagram of Dalihe Watershed is used in Figure 1 Institute (DVM).

Vegetation cover fractional brownian motion model

Random Brownian motion, promoted by Mandelbrot, is an independent incremental balance process. It defines Fractional Brownian motion and has statistical self-similarity. Fractional Brownian motion is widely exploited in describing natural mountains, clouds and terrain. On the basis of fractional Brownian motion and DVM, this paper promotes vegetation cover fractional Brownian motion model, described specifically as follows.

$I(x_0,y_0)$ represents (x_0,y_0) of NDVI values in the DVM, $I(x,y)$ represents NDVI values of other points of watershed, $I(x_1,y_1)$ represents NDVI values of the distance of a unit point with $I(x_0,y_0)$. By the nature of fractional Brownian motion can be obtained:

$$E\{|I(x,y)-I(x_0,y_0)|\}=E\{|I(x_1,y_1)-I(x_0,y_0)|\}\cdot r^H,\ r>1 \quad (1)$$

Where: H is Haustein index, r is the distance between the points of (x,y) and(x_0,y_0), calculated as follows:

$$r=\sqrt{(x-x_0)^2+(y-y_0)^2} \quad (2)$$

If we define

$$\left|\Delta I(r)\right| = \left|I(x,y) - I(x_0,y_0)\right| \qquad (3)$$

The Equation (1) can be rewritten as

$$E\left\{\left|\Delta I(r)\right|\right\} = E\left\{\left|\Delta I(1)\right|\right\} \cdot r^{H} \qquad (4)$$

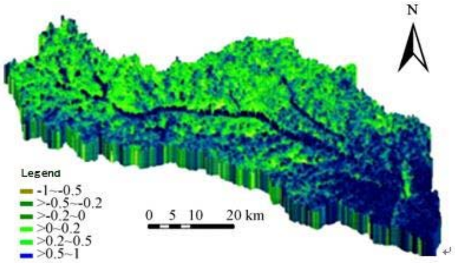

Figure 1. Digital vegetation model diagram of Dalihe Watershed.

H parameters is obtained by simultaneously logarithm icing both sides of the Equation (4), and watershed vegetation pattern FBM fractal dimension is obtained according to the nature of fractional Brownian motion surface. These are calculated as follows:

$$H(r) = \lim_{r\to 0} \frac{\left|Lg\left(E\left\{\left|\Delta I(r)\right|\right\}\right)\right|}{Lg\left(r\right)} \qquad (5)$$

$$F_D = D_E - H(r) \qquad (6)$$

Where: F_D is vegetation patterns basin FBM fractal dimension, D_E is the dimension of the three-dimensional shape of the basin Euclidean topology, $D_E = 3$.

The calculation of vegetation cover fractional brownian motion fractal dimension

When using statistical methods to carry out vegetation cover FBM fractal calculation, we firstly calculate NDVI increment value of the watershed points at a certain spatial scale (distance r), and then computerize mathematics expectations $E\{\Delta I(r)\}$ of measure collection $\Delta I(r)$ of the composition of all NDVI incremental values. In this paper, we achieve to measure the points on the watershed NDVI increments through developing GIS algorithm, establishing measurements and using moving window method in the research process. Figure1 is a schematic diagram of the calculation method of the moving window NDVI increment.

As it can be seen from Figure 2, the so-called moving window statistics is to divide the whole basin into a number of equal DVM cell(r × r, r is an odd multiple of the pixel size, r>1), and each cell is called a "window". We computerize the difference of NDVI values ΔI1(r) between each pixel point by point.

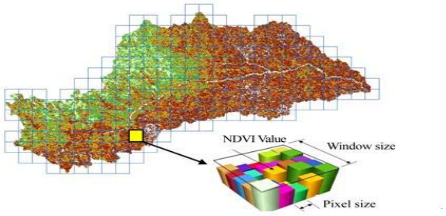

Figure 2. Calculation schematic diagram of NDVI (normalized difference vegetation index) distribution increment by moving window analysis.

Point in the r × r rectangular window centers on (x_0, y_0) and the center pixel point (x_0, y_0). The incremental value of all the cells within the entire basin is calculated successively by moving analysis window. Then we can see from the definition and nature of the fractional Brownian motion, fractional Brownian motion is zero mean Gaussian balancing process, which meets mean after sex, there:

$$E\left\{\left|\Delta I(r)\right|\right\} = \frac{1}{N_r}\sum_{r\rangle 1}\left|\Delta I_i(r)\right| \qquad (7)$$

The equation: N_r is the total number of the whole basin "window"; the mathematical expectation $E\left\{\left|\Delta I(r)\right|\right\}$ is calculated by the Equation (7). It can be obtained according to watershed vegetation cover FBM self-similarity:

$$E\left\{\left|\Delta I(r)\right|\right\} = E\left\{\left|\Delta I(1)\right|\right\}\cdot r^{H} \qquad (8)$$

Both sides of the equation with logarithmic get:

$$Lg\left(E\left\{\left[\Delta I(r)\right[\right\}\right) = H\cdot Lg\left(r\right) + Lg\left(E\left\{\left|\Delta I(1)\right|\right\}\right) \qquad (9)$$

Statistical self-similarity in the performance of such increments is manifested that, for certain observations within the range of scales *r*, $Lg\left(E\left\{\left|\Delta I(r)\right|\right\}\right)$ and $Lg\left(r\right)$ of FBM should be line with H to the slope, the intercept of $Lg\left(E\left\{\left|\Delta I(1)\right|\right\}\right)$. To this end, on the basis of measurement on basic features combined with a moving window method and GIS technology, we proposed calculation sub-model based on self-similarity of surface vegetation patterns basin FBM fractal dimension in this paper, just as follows:

$$H(r) = \lim_{r\to 0}\frac{\left|Lg\left(E\left\{\left|\Delta I(r)\right|\right\}\right)\right|}{Lg\left(r\right)} \qquad (10)$$

$$F_D = 3 - H(r) \qquad (11)$$

To determine the scale-free interval by linear regression analysis, slope of the line in the scale-free interval range is Haustein Index *H(r)*.Watershed vegetation pattern FBM fractal dimension FD can be obtained by the Equation (11).

DATA AND PROCESSING

Overview on study area

In the northern part of Shaanxi Province, Dali River Basin (longitude 108 ° 53 '~ 110 ° 16', latitude 37 ° 12 '~ 37 ° 50') for the study, is the largest tributary of the River Wudinghe. The length of its main stream is170km, the riverbed dropped to 3.16 ‰, and the basin area is of 3906km^2. It mainly consists of Heyuan area and hilly area. Heyuan area is in the upstream of the main stream, accounting for 16.9 percent of the watershed area; River basin is located in the hilly region, accounting for 71.9% of the total watershed area. This is a typical continental monsoon climate with annual average temperature of 7.8 ~ 9.6℃, annual average evaporation of 1515mm, annual average rainfall of 439.8 mm, and annual precipitation of more than 60% in 7~9 monthly.

Basin scale division

To study characterization of fractal dimension and its variation at different scales of the features of the vegetation cover, it is divided into four sections according to the area of the basin, with five times per level descending. The first section is the entire Dali River Basin with an area of 3906 km^2, approximately pixel size (30 × 30m) of 500 times. Dali River Basin, the second section will be divided into three parts, namely upstream, midstream and downstream, with an average area of approximately 1000 km^2, approximately pixel size (30 × 30m) of 100 times. The third section will be divided into 14 small Dali River Basin, with an area of 179.4 ~ 392.5 km^2, the average area of about pixel size (30 × 30m) 20 times. The fourth section will be divided into 53 small Dali River Basin (No. 1 to 53), with an area of 21.9 ~ 108.9 km^2, the average area of about pixel size (30 × 30m) 4 times. The concrete structure is shown in Figure 3 as below.

Figure 3. Map of Dalihe river basin and its sub-watershed.

Note: The number 1~53 represents that Dalihe river basin is divided into 53 watershed. The same is as below.

RESULTS AND ANALYSIS

The basic characteristics of NDVI values

From the entire basin, the mean NDVI value of the basin is 0.221, the coefficient of variation of NDVI pixel values is 0.377. NVDI pixel values of 35% of the whole basin lies between 0.1 to 0.2, of 42% lies between 0.2 and 0.3. Pixel area greater than 0.4 and smaller than 0.1 occupied by a very small proportion, 8.2%, and the area greater than 0.2% of the total account for 58 Dali River Basin area. From upstream to downstream of watershed perspective, the mean value of NDVI in turn increases by 0.193,0.214 and 0.259respectively, the coefficient of variation million decreases in NDVI values by 0.40,0.39 and 0.29 respectively and is a moderate variation. NDVI values of 0.1 to 0.2 mains in the upstream, as 0.2 to 0.3 mains in the downstream. The area of NDVI values greater than 0.2 of upstream, midstream and downstream respectively account for 43%、54% and 79% of the total. From 14 small watershed of 179.4 ~ 392.5 km^2 perspective, the mean NDVI values lies between 0.155 ~ 0.268, mean coefficient of variation of NDVI value is 0.17, the coefficient of variation per NDVI values in different basins lies between 0.27~0.42, small watershed tended to decrease from upstream to downstream(Table 1). In Figure 4a, it shows proportion of 14 small watersheds pixel NDVI value. And 84% of 68% of NDVI pixel values of 14 small watersheds lies between 0.1 ~ 0.3, NDVI values greater than 0.2 accounts for the percentage of the basin area raging from 22% to 84%. It tends to increase from upstream to downstream, especially the NDVI values within the range of 0.2 to 0.4. From 53 small basins of 21.9 ~ 108.9 km^2 perspective, the further analysis of the mean NDVI spatial variability shows that the mean NDVI values of 53 small watershed lies between 0.133 to 0.287, the mean NDVI coefficient of variation of each small watershed is 0.175, and the coefficient of variation in NDVI values of different small watershed lies between 0.26 to 0.47. In Figure 4b, it shows that the percentage of area of different grades of NDVI values in the total area of 53 small watersheds. 59% to 90% of the pixel NDVI values lies between 0.1 to 0.3, and they are in dominant place. The number of NDVI values greater than 0.2 accounts for about 11% -88% each small drainage area. Pixel NDVI value of each small watershed lies mostly 0.1 to 0.2 in the upstream,0.2 to 0.3 in the upstream and is relatively complicated in the midstream.

Haracterization meaning of the vegetation covers of the fractal dimension

According to the Equation (9) and Equation (11), FBM fractal dimension is calculated under different scales watershed vegetation cover (FD), the results are shown in Table 1. When moving boxes, linear regression coefficients R2 of a fitting straight line of $Lg\left(E\{|\Delta I(r)|\}\right)$ and $Lg(r)$ reached 0.91 or more, a maximum of 0.99. This shows that the ratio of $Lg\left(E\{|\Delta I(r)|\}\right)$ and $Lg(r)$ is of self-similarity statistically, and the calculation of the watershed vegetation cover FBM fractal characteristics of scale invariance is an objective reality, and the vegetation cover of the watershed is of obvious fractal nature. According to the theory of Brownian motion, $Lg\left(E\{|\Delta I(r)|\}\right)$ actually reflects the difference of NDVI values of different pixels in the basin, and is the overall summarization of the distribution complexity of NDVI values in the basin. For specific watershed, when moving box size is fixed, the value of corresponding $Lg\left(E\{|\Delta I(r)|\}\right)$ is greater, NDVI values changes in watershed vegetation more intensely, vegetation cover is more complex, and vice versa. Therefore, the increment ratio of $Lg\left(E\{|\Delta I(r)|\}\right)$ and $Lg(r)$ is indicators of reflection of the entire watershed vegetation cover general characteristics, and FBM fractal dimension can be used to express the complexity of the spatial distribution of vegetation cover.

Haustein index H of the digital distribution model FBM vegetation is less than 0.5, the fractal dimension is greater than 2.5 by the results in Table 1. According to the theory of Brownian motion, the closer to 0.5 Haustein H index is, the closer to the random Brownian motion the spatial distribution of surface states is, and the greater the degree of fragmentation of research and complexity of the surface is. Therefore, in this study for the establishment of vegetation covering the fractal dimension, the smaller the value is, the more complex fragmentation the spatial distribution of digital vegetation distribution model is. Conversely, the greater its value is, the more structured the figures may reflect the spatial distribution of vegetation model. When Haustein H index is zero and vegetation cover FBM fractal dimension reaches 3, the vegetation cover is presented as a uniform distribution in the space.

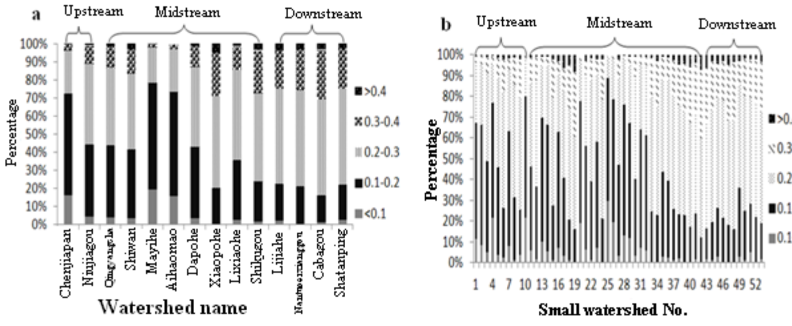

Figure 4. Percentage of the given NDVI area accounted for the watershed area for fourteen (a) and fifty-three (b) sub-watersheds.

The upstream in Dali River Basin of vegetation cover FBM fractal dimension is 2.810, the midstream is 2.816, the downstream is 2.814. The fractal dimension of the smallest upstream vegetation, indicating vegetation cover change, is a more complex space in the upstream watershed. It may be related to the upstream surface characteristics and the types of land use variation. The Dali river basin is divided into 14 areas

Table 1. The calculated results of fractal dimension of FBM for watershed vegetation cover.

Order	Watershed name	Area/km^2	Equalization of NDVI value	Coefficient variation	Horst index	Fractal dimension
First order	Dalihe	3758	0.221±0.083	0.377	0.1834	2.8166
Second order	Upstream	627	0.193±0.077	0.401	0.1856	2.8098
	Midstream	2251	0.215±0.083	0.387	0.184	2.816
	Downstream	880	0.259±0.075	0.291	0.1902	2.8144
Third order	Chenjiapan	274	0.166±0.069	0.416	0.2108	2.7892
	Niujiagou	353	0.214±0.075	0.353	0.2083	2.7917
	Qingyangcha	390	0.219± 0.077	0.353	0.2081	2.7919
	Shiwan	353	0.226 ±0.083	0.367	0.2187	2.7813
	Mayihe	211	0.155±0.064	0.413	0.2099	2.7901
	Aihaomao	393	0.219±0.073	0.335	0.1928	2.8072
	Dapohe	254	0.264±0.078	0.296	0.1984	2.8016
	Xiaopohe	289	0.166±0.067	0.401	0.1863	2.8137
	Lixiaohe	171	0.229±0.071	0.311	0.2174	2.7826
	Shikugou	191	0.256±0.083	0.324	0.206	2.794
	Lijiahe	181	0.255±0.080	0.314	0.2059	2.7941
	Nantuoerxianggou	234	0.268±0.071	0.266	0.2172	2.7828
	Cabagou	208	0.258±0.072	0.277	0.2111	2.7889
	Shatanping	255	0.254±0.077	0.305	0.2273	2.7727
Fourth order	1	106	0.176±0.069	0.395	0.2140	2.7860
	2	69	0.179 ±0.072	0.400	0.2504	2.7496
	3	76	0.207±0.072	0.349	0.2289	2.7711
	4	71	0.157±0.073	0.469	0.2393	2.7607
	5	90	0.213±0.073	0.341	0.2159	2.7841
	6	53	0.242±0.073	0.302	0.2731	2.7269
	7	32	0.189±0.075	0.396	0.2775	2.7225
	8	28	0.234±0.065	0.277	0.2927	2.7073
	9	36	0.241±0.083	0.343	0.2615	2.7385
	10	65	0.151±0.066	0.439	0.2549	2.7451
	11	34	0.212±0.079	0.370	0.2452	2.7548
	12	93	0.226±0.064	0.283	0.2300	2.7700
	13	81	0.176±0.068	0.385	0.2061	2.7939
	14	52	0.185±0.064	0.346	0.2548	2.7452
	15	48	0.245±0.071	0.291	0.2391	2.7609
	16	54	0.193±0.083	0.429	0.2207	2.7793
	17	22	0.233±0.094	0.402	0.2423	2.7577
	18	60	0.261±0.079	0.303	0.2064	2.7936
	19	58	0.283±0.082	0.291	0.2494	2.7506
	20	127	0.156±0.065	0.420	0.2431	2.7569
	21	28	0.200±0.083	0.416	0.2889	2.7111
	22	33	0.225±0.066	0.294	0.2425	2.7575
	23	35	0.196±0.080	0.407	0.3053	2.6947
	24	55	0.253±0.066	0.261	0.2340	2.7660
	25	113	0.134±0.053	0.401	0.1984	2.8016
	26	84	0.154±0.062	0.403	0.2445	2.7555
	27	89	0.213±0.075	0.351	0.2129	2.7871
	28	116	0.163±0.062	0.379	0.2146	2.7854
	29	48	0.178±0.069	0.389	0.2835	2.7165
	30	37	0.218±0.069	0.314	0.2964	2.7036
	31	78	0.184±0.063	0.344	0.2592	2.7408
	32	128	0.190±0.070	0.368	0.2360	2.7640
	33	126	0.247±0.067	0.273	0.2052	2.7948

34	51	0.256±0.072	0.281	0.2334	2.7666
35	65	0.217±0.070	0.321	0.2691	2.7309
36	35	0.221±0.069	0.315	0.2489	2.7511
37	72	0.245±0.071	0.288	0.1994	2.8006
38	94	0.255±0.083	0.327	0.2085	2.7915
39	57	0.260±0.074	0.286	0.2137	2.7863
40	35	0.273±0.076	0.280	0.2481	2.7519
41	191	0.256±0.083	0.324	0.2056	2.7944
42	52	0.287±0.075	0.262	0.2503	2.7497
43	50	0.272±0.082	0.301	0.2062	2.7938
44	63	0.259±0.072	0.277	0.2153	2.7847
45	45	0.246±0.085	0.346	0.2055	2.7945
46	35	0.254±0.067	0.265	0.2441	2.7559
47	117	0.268±0.074	0.277	0.1894	2.8106
48	209	0.268±0.071	0.266	0.2216	2.7784
49	23	0.229±0.082	0.359	0.2291	2.7709
50	83	0.246±0.067	0.272	0.1985	2.8015
51	60	0.239±0.084	0.352	0.2434	2.7566
52	60	0.254±0.068	0.267	0.2173	2.7827
53	135	0.261±0.077	0.297	0.1992	2.8008

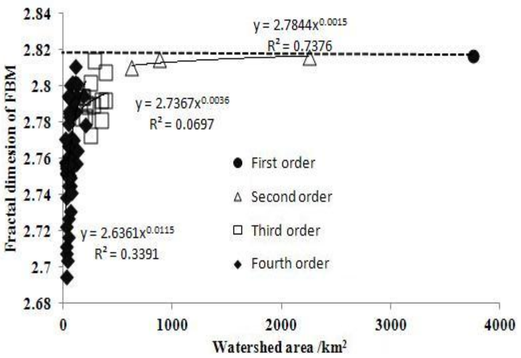

Figure 5. Fractal dimension of fractional Brownian motion for watershed vegetation cover vs. watershed area.

in 179.4 ~ 396.5 km^2 Small Watersheds, The small watershed vegetation coverage of FBM fractal dimension between 2.773 ~ 2.814. And divide into 53 areas in 21.9~208.9 km2 Small Watersheds. The small watershed vegetation coverage of FBM fractal dimension is between 2.695 ~ 2.811. From upstream to downstream, Vegetation cover FBM fractal dimension has increased and decreased variability trends (Table 1).

The fractal dimension of the scale effect of vegetation cover

Chart 4 is on the relationship between FBM and fractal dimension of the small watershed area and vegetation area covered by four different levels of. From the Figure 5, in four area scale, fractal dimension presented have scale effect. From the overall trend, the area level, the fractal dimension of the fractal dimension of the size of the vegetation coverage was less than the larger watershed here, which is, no more than the downstream of Dali River. Chen Jia fan, Niu Jia Gou does not exceed the upper; 1, 4, 7, 10 more than Chen Jia fan. This conclusion is consistent with the actual rules that the distribution of vegetation complexity area greater than the complexity of vegetation distribution area level.

In addition, when in the third and fourth section, the small watershed changes little, vegetation cover fractal dimension by the size of the impact is very small and is distribution fractal dimension. When the area increases to a certain extent, it reaches to the second and the first section, vegetation cover fractal dimension tends to be stable, whose range of variation is very small. The overall trend is that with increasing drainage area scale, the fractal dimension of fractal dimension approximation of the entire basin covering all levels of small watershed vegetation cover also accords with the actual rule.

With the increase of watershed area, vegetation cover FBM fractal dimension gains an increase also. When the watershed area is not large, the vegetation coverage area is affected by FBM fractal dimension. On the whole, when the area increases to a certain degree, vegetation cover FBM fractal dimension tends to be stable with a small range of variation, which shows that vegetation cover FBM fractal dimension have scale effect. The cause of this scale effect may be associated with different NDVI values within the watershed pixel number. If the same NDVI pixel is classified into a class, there will be more categories within the watershed pixels, and then the change of vegetation cover may be more complex. Figure 6 is on the relationship between the number of pixel area and the basin with different NDVI values, found with increasing drainage area, the numbers of pixels with different NDVI values increase rate decreases, it shows that the increase of watershed area, different NDVI value of unit area of the pixel number in reducing. Figure 7 shows the relationship between the pixel number of different NDVI value of unit area and vegetation covers between FBM and fractal dimension, it finds that the two linearly, the correlation coefficient is -0.663 ($p<0.01$), which prove the complexity of FBM fractal dimension of spatial distribution of vegetation coverage of vegetation.

CONCLUSIONS

1) This paper, with the construction of digital vegetation NDVI model based on NDVI and the presentation of the calculation model of the FBM fractal dimension of watershed vegetation coverage, through calculation and analysis, approves that the spatial distribution characteristics are similar to watershed vegetation coverage and FBM can be used to characterize the fractal dimension.

2) According to the calculation results show, we found that vegetation cover FBM fractal dimension between 2.5~3, the closer it is to 2.5, the more complex of the changes that within the catchment vegetation cover; the closer to 3, the more structured vegetation is.

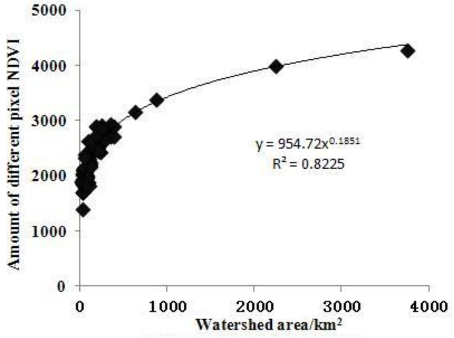

Figure 6. Numbers of different pixel NDVI vs. watershed area.

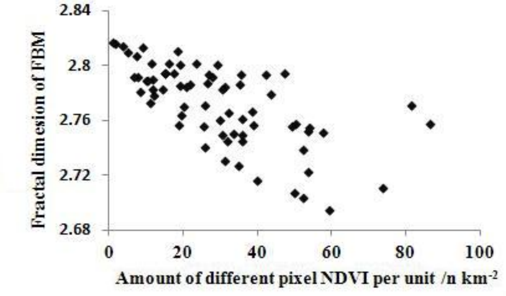

Figure 7. Numbers of different pixel NDVI vs. watershed area and fractal dimension of fractional brownian motion for watershed vegetation cover vs. numbers of different pixel NDVI per square kilometer

3) The studied area, vegetation cover fractal dimension between 2.695~2.817 in different area of scale, with the increase of vegetation coverage area, FBM fractal dimension is a power function that is increased, but the increase is smaller and smaller, which is beyond a certain area; vegetation cover FBM fractal dimension tends to be stable, fractal dimension and infinite close to the whole basin. The vegetation cover, FBM fractal dimension is scale effect.

4) The FBM fractal dimension of watershed vegetation coverage basin is the mean NDVI values of vegetation quantity characteristic indexes of beneficial supplement, which can quantitatively describe the distribution characteristics of watershed vegetation coverage space from the integrated, holistic and scientific aspects.

This paper firstly tries to put forward the calculation model of FBM fractal dimension of watershed vegetation coverage based on the pixel values of NDVI, according to the remote sensing data of Dali River Basin; while for FBM fractal dimension cover comprehensive effect characteristic to vegetation, whether can be used as a fixed parameter, phase combined with the quantitative index of vegetation cover, surface hydrology, in soil erosion, nutrient loss and mass transfer process in the application of prediction is not involved in this paper. The future research is the key aspects that the vegetation FBM fractal dimension is effective and it applies to the actual hydrological and soil erosion prediction process.

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