Research Article

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Multifractal analysis of temporal and spatial characteristics of earthquakes in Eurasian seismic belt

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Abstract: Seismic activity has complexity and randomness, and its temporal and spatial distribution has complexity, stage, level, and inheritance. The study of the temporal and spatial distribution characteristics of seismic activity is of great significance to the understanding of the law of seismic activity, such as the law that the time series of seismicity in the seismic belt is consistent with the complexity of geographical structure, the prediction of seismic risk, and other research related to earthquake. This article selects the seismic data catalog of the whole Eurasian seismic belt as the research object. Based on the characteristics of the seismic geological environment and tectonic environment characteristics, the multifractal analysis method is used for the seismic data of the seismic activity directory. The results show that the seismic activity of seismic zones has obvious multifractal structure of complex in time series and spatial scales, which can well reveal the seismic characteristics of seismic activity in time and space. In terms of time series, the study area decreases significantly with time and energy before the occurrence of a large earthquake, and the time series of seismic activity in the study area is highly complex and highly correlated with the geological structure. Spatially, the spatial distribution of seismic intensity in the study area is infinite and sparse, showing the characteristics of infinite clustering. Therefore, it can reveal the basic rule of seismic activity effectively and lay a certain theoretical foundation for earthquake prevention and control in this seismic zone.

Keywords: Eurasian seismic belt, multifractal, multi-analysis, multi-analysis spectrum, spatial-temporal characteristics

1 Introduction

At present, human beings are faced with many natural disasters and environmental problems caused by social activities. As a natural disaster, earthquake has brought a lot of losses to human beings [1,2]. With the development of neural network and image technology [3], some abnormal phenomena are often the focus of people's attention and research hotspot in the study of earthquake precursor in earth science.

In 1976, French mathematician Mandelbrot proposed the concept of fractals [4]. With the rapid development of nonlinear dynamics theory, computer theory, and electronic computer graphics display technology, the fractal theory has become one of the powerful tools for the analysis of the phenomenon that seemingly irregular and complex.
Fractals play an important role in various fields. In the study of the mechanical properties of materials, the fundamental nature of scaling laws for both strength and toughness is deeply connected with fractal–statistical aspects [5]. In porous media, a fractal method was established in order to evaluate the permeability of compressible gas flow through a porous restrictor in aerostatic bearings [6]. This study is of particular importance since it proves that the permeability for compressible gas flow through a porous restrictor in aerostatic bearings can be precisely predicted by fractals analysis [7]. In the field of biology, fractal analysis is the most valuable mathematical tool for measuring dimensional, geometrical, and functional parameters of biological cells, tissues, and organs [8].

Fractal theory plays an important role in science because they are a key representation of self-similarity observed at many different scales. In biology, fractal structures have been found in many organisms such as tree branches, lung bronchi [9], heart valves [10], and neural system [11]. The self-similarity of these structures allows organisms to operate efficiently and adapt to changes in their environment. In medicine, fractal analysis techniques can be used to diagnose and treat a variety of diseases such as arrhythmias [12] and epilepsy [13]. Fractal analysis can also be utilized to analyze and improve medical images such as segmenting and analyzing CT scan images [14,15]. In materials science, fractals can be applied to describe the surface morphology [16] and properties of materials, such as material strength [17]. Fractal analysis can also be employed to optimize the preparation and performance of materials, such as the preparation and characterization of nanomaterials [18]. In elasticity theory, fractals can be used to describe the geometric shape and mechanical properties of materials, such as their strength and toughness. Fractal analysis can also be employed to study the behavior of complex mechanical systems, such as earthquakes [19] and fluid dynamics [20]. In quantum mechanics and molecular physics, fractals can be used to describe the structure and properties of molecules and materials, such as protein and DNA [21]. Fractal analysis can also be utilized to study the behavior of quantum mechanical systems, such as quantum computing [22] and quantum information [23]. In astronomy, fractals can be used to describe the shape and properties of celestial bodies such as nebulae and galaxies [24]. Fractal analysis can also be applied to study the structure and evolution of the universe, such as large-scale structure [25] and cosmic microwave background radiation [26]. Fractal and fractal dimension theory has the potential for studying seismicity.

When the fractal theory is introduced into the field of earthquake precursors and large earthquake prediction [27], a large number of related studies show that before large earthquakes, the fractal dimension of seismic time series and spatial distribution series will be abnormal, and people can predict earthquakes by this kind of abnormality, which makes the fractal superior among the approaches mentioned earlier. With the continuous application of fractal theory to the earthquake research [1,2], the researchers increasingly found seismic activity on the time series, and spatial sequence on its characteristics is not a single fractal process, but a process of multiple fractal. Multifractals are relative to and developed on the basis of single fractals. Previous studies have shown that the fractal dimension of earthquake time and space usually has obvious anomalies before large earthquakes. Power et al. obtained the multifractal spectrum of the rupture surface by analyzing fractal dimension. Accordingly, the author found the nonuniform distribution of the natural fault plane [28]. Rawat et al. used the power spectrum (FFT) method and the Higuchi method to estimate the fractal dimension and analyze the variability of the dimension. The fractal dimension observed in other parts of the world increases gradually before earthquakes, which is considered the precursor feature of electromagnetic field emission from earthquakes [29]. Hamdache et al. conducted cluster analysis of the study area based on fractal dimension, highlighting the importance of fractal dimension research in seismic sequence [30]. Among all kinds of natural phenomena, earthquake is generally regarded as a natural phenomenon with the characteristics of scale invariance, and the statistical analysis of the phenomenon by using the fractal statistics principle shows that the phenomenon is a random self-organized critical process [27,31–34]. Therefore, there exists a critical state for seismic activity in a certain region, and the critical state generally does not need to adjust the relevant global variables. In the calculation process, once the variables reach the pre-set critical value, the unstable phenomenon will suddenly occur, and the similar phenomenon will continue until the whole scale is involved.

Multifractals are used to analyze and study the time series, spatial distribution series, wide stress release, and intensity of seismic activities in the study area and obtain their corresponding characteristics [35–37]. In addition, studies have shown that there is a direct relationship between seismicity and active fault zone, and seismicity has obvious stages or periodicity, in which strong seismicity is the center and complex fluctuation is carried out [38]. When the multifractal theory is applied to the study of the temporal and spatial characteristics of earthquakes and the calculation of their energy release dimension, it is worth noting that the boundary conditions of the study...
area, the measurement process, and the size of the data have important effects on these results. Therefore, although there have been a large number of methods aimed at improving the accuracy and reliability of seismic dimension measurement, no breakthrough results have been achieved, which is a key point and a bottleneck. If a breakthrough can be achieved in this field, the theory can be applied to the study of the temporal and spatial propagation characteristics of earthquakes, and better regularity of seismic activity will be obtained, which will undoubtedly be a breakthrough in the prediction of earthquakes and other aspects.

In this study, we downloaded the original seismic data from the official website of the United States Geological Survey (USGS). Then, the multifractal analysis of their temporal and spatial characteristics is carried out as follows: First, we divided the study area into grids according to different spatial attributes, and obtained the attribute information of each cell after discretization is calculated. Then, the seismic energy in each grid was calculated and analyzed. Finally, the multifractal spectrum of the time and spatial distribution sequence of earthquakes within the seismic zone was obtained.

2 Study area and data

2.1 The study area

This article selects the study area for the whole of the Eurasian seismic belt, as shown in Figure 1 [39]. It is the world’s second largest Eurasian seismic zone [40], and most are shallow earthquake, which makes the seismic activity of the seismic zones in the region, and its area affected by a disaster is particularly serious and forms a considerable threat to people’s life and property safety and normal life. At the same time, this seismic zone not only has the world’s highest peak of the Himalayan mountains but also has winding rivers, which makes the geological structure very complex in this region, and under the strong movement of old structure and modern structure, active faults are constantly gestation. In the historical record, there have been several large earthquakes of magnitude 7 and above. In addition, the seismic zone involves a wide range and affects a large area. Therefore, it has become extremely important and urgent to analyze the earthquakes in the seismic zone in order to obtain the spatial–temporal

Figure 1: Seismicity of the Earth (1900–2018) [39], reedited by the authors, the Eurasian seismic belt was marked by pink.
propagation characteristics of the seismic activity [41], so as to predict the seismic activity in the seismic zone.

2.2 Data and pretreatment

The data used in this article were the original seismic data downloaded from the official website of the USGS, ranging from longitude [63°, −12.2°] and latitude [−13.3°, 133°] from January 1900 to January 2022. The original data mainly include the attribute information of the time, longitude, latitude, magnitude, depth, and source of the earthquake [42]. First, the downloaded data need to be transformed into text format, then imported into ArcGIS, and transformed into its coordinate system and projection. In this article, the WGS1984 coordinate system was adopted, and then seismic data within the range of the Eurasian seismic belt was trimmed and merged.

Second, the Eurasian seismic belt is discretized with different resolutions. From the operational point of view, it is actually to establish regular grids, so that the seismic data in the study area can be divided into different grids according to certain standards. The length of the grid will directly affect the final result, so its size is critical. Due to the wide range of the Eurasian seismic belt, if the length of the grid is too large, it will directly lead to the characteristics of the low-occurrence area, which is difficult to discover, or even ignored. On the contrary, if the mesh length is too small, it will not only greatly increase the amount of computation but also cannot dig out more meaningful information. Therefore, based on the previous research and combined with the actual situation of the research area [1,2,37], the final determination of the division scale is 1°, and it was used for discretization. After the grid, it is necessary to build the topological surface of the divided grid layer and then to superimpose the layer of the built grid surface and the layer of seismic point elements, so that the seismic point data in each grid corresponding to the grid can be obtained. Finally, the information on seismic points in each grid cell will be counted. The partition results of this seismic zone grid are shown in Figure 2.

The discrete scale of an earthquake usually refers to the magnitude of the Richter scale earthquake, which is a commonly used indicator of earthquake intensity. It calculates the magnitude of an earthquake by measuring the amplitude and period of seismic waves. The magnitude of the Richter scale earthquake is usually expressed in M, and its value is related to the energy released by the earthquake. Each increase of one M value increases the energy released by the earthquake by about 32 times. Due to the low destructive power of low-grade earthquakes, only earthquakes above magnitude 4.5 in the study area were selected for analysis, and a total of 50,657 seismic point information was extracted after the aforementioned process. Figure 2(a) shows the different number of earthquakes in each grid to understand areas of seismic density, and it can be found that in the most dense grid, there were 1,019 earthquakes that happened in 1,900–2,022. Figure 2(b) shows the different magnitudes represented by these points, and it can be seen from Figure 2(c) that most of the earthquakes has a magnitude under 5.0. Figure 2(d) shows that earthquakes with a focal depth of less than 50 km accounted for more than 73% of all earthquakes in the region.

3 Methods

Multifractal analysis is related to the single fractal analysis. It is much more suitable for analyze the temporal and spatial characteristics of earthquakes than single fractal because the multifractal analysis considers the nuances between each box cover graphics, and extracted respectively each box inside information, the use of statistical methods were normalized processing, finally get the multifractal spectrum. Therefore, this method can give a more reasonable and detailed description of the research object. In addition, the method of multifractal fractal dimension can be used to restore the distortion of analysis results caused by ignoring the differences in each box.

Therefore, the multifractal method was adopted in this study. This study uses MATLAB 2019b for the multifractal analysis after obtaining data and preprocessing, and this chapter focuses on the definition and equations of multifractal analysis and multifractal spectra.

3.1 Multifractal analysis

The most common method to describe multifractals is generalized fractal dimension, and its definition will be described below [43,44].

Multifractal analysis analyzes a series of scale r through the spatial distribution of measure $P_r(r)$ and then observes the result of the function as $r$ changes. For the $g$ degree probability moment, its definition formula is expressed as follows:

$$X_{q}(\varepsilon) = \sum_{i} P_{i}(\varepsilon)^{q}, \quad (1)$$

where $\varepsilon \to 0$, then
Figure 2: The grid division Eurasian of seismic belt (a) and (b), and statistics of magnitudes and focal depths (c) and (d) [42].
\[ X_q(\varepsilon) \propto \varepsilon^{(q-1)D_q}. \]  

In the formula, \( D_q \) is the generalized dimension.

According to different \( q \) values, the definition of \( D_q \) is divided into two situations:

\[
D_q = \begin{cases} 
\lim_{\varepsilon \to 0} \frac{\sum P_i \cdot \lg P_i}{\lg \varepsilon}, & (q = 1) \\
\frac{1}{q-1} \lim_{\varepsilon \to 0} \frac{\lg \sum P_i^q}{\lg \varepsilon}, & (q \neq 1).
\end{cases}
\]  

In addition, multifractals can also be described from the perspective of the multifractal spectrum, which is defined as follows [45].

Here, the research objects need to be partitioned according to \( \varepsilon_i \) of different scales. The total number of partitions is denoted as \( N(\varepsilon) \), the corresponding region is denoted as \( S_i \), and their respective corresponding probability is \( P_i = P(i = 1, 2, L, N) \). When \( S_i \) is small enough, it can be considered as follows:

\[ P_i = \varepsilon^{a_i}, \]  

where \( a_i \) is the scale index, also known as singular strength [41].

Among numerous \( a_i \), the number of regions \( N(\varepsilon) \) with the same \( a \) value is related to the scale \( \varepsilon_i \), and the relationship between the two can be expressed by the following formula:

\[ N(\varepsilon) \propto \varepsilon^{-f(a)}, \]  

where \( f(a) \) represents the proportion of \( a \) in the population and is a continuous derivative of \( a \). From this, multifractal spectrum \( f(a) \) spectrum can be constructed.

After Legendre transformation, the relationship between \( D_q \) and \( f(a) \) can be obtained:

\[
\alpha = \frac{d}{dq}((q-1)D_q),
\]

\[
f(a) = qa - (q-1)D_q.
\]

If \( \tau(q) = qa - f(a) \) is given, then:

\[
\tau(q) = (q-1)D_q,
\]

\[
\alpha = \frac{d\tau(q)}{dq},
\]

\[
f(a) = qa - \tau(q).
\]

It can be seen that \( D_q - q \) and \( f(a) - \alpha \) are equivalent to each other and can evaluate each other, and both are key functions of multifractal spectrum.

### 3.2 Multifractal analysis spectrum

Multifractals are also called fractal measures. According to the singularity of the measure, the study area is decomposed according to certain rules, and a certain number of subregions can be obtained after decomposition. For each subregion, it is essentially a single fractal. Therefore, each subregion after decomposition not only has a fractal dimension but also has the singularity of the measure. The aforementioned process is the basic idea of obtaining multifractal spectrum, and the following process will be described [46].

The research object of multifractal analysis is usually a series of attribute values that change over time, or a series of things that are regularly distributed in the spatial distribution sequence. The steps to obtain a multifractal spectrum mainly include: First, the research object is divided into \( N \) units \( S_i(i = 1, 2, \ldots, N) \) with different scales according to the fractal principle; then, the probability \( P_i \) of the object with the research attribute in each region is calculated. Then, the attribute information in each unit is statistically analyzed. Finally, the multifractal spectrum can be obtained by analysis on the basis of the above steps [47].

Therefore, to obtain multifractal spectrum of seismic activity in the Eurasian seismic belt, it is necessary to divide it into different scales with different standards. For the earthquakes in this seismic zone, the time series should be divided into different time periods, where \( r \) represents the size of the line degree in the \( i \) region.

Then, the generation probability \( p_i \) of \( s_i \) for each region of seismic activity in the seismic belt is calculated. In the time period divided, \( s_i \) of each region is not independent, but occupies a certain proportion in the whole, which is denoted as \( p_i \), and the overall relationship between \( p_i \) is \( \sum_{i=1}^{N} p_i = 1 \). Therefore, \( p_i \) corresponding to different regional unit \( s_i \) is also different. The scale index \( a_i \) is used to represent the difference, and the relation between it and \( p_i \) can be connected by the linear degree \( r_i \). The relation can be expressed in formula (11), where \( a_i \) Holder index is essentially the corresponding fractal dimension of each region in the multifractal. That is, local partial dimension, which directly reflects the probability of generating the \( i \) region.

\[ p_i = r_i^{a_i}(i = 1, 2, \ldots, N), \]

When \( r_i \to 0 \), the above formula can be simplified as:

\[ a_i = \lim_{r_i \to 0} \frac{\ln p_i}{\ln r_i}. \]
Then, the attribute information in each unit is statistically analyzed. A series of time segments are divided, and then each time segment is continuously divided until the value of each small unit is the same. Then, the relationship between \( n_p(e) \) and \( e \) relative to the number of units in each unit can be expressed as follows:

\[
N_p(e) \propto e^{-f(a)},
\]

Finally, according to the above analysis, the multifractal spectrum of earthquakes in this seismic zone is obtained. Its expression is:

\[
f(a) = -\lim_{e \to 0} \frac{\ln N_p(e)}{\ln e}.
\]

The singular spectrum \( f(a) \) represents the fractal dimension of units with the same value. Based on this, the units with different values corresponding to different regions are combined to obtain a series of spectra, namely, the multifractal spectrum, and \( f(a) \) generally presents single-peak images [48].

In addition to being represented by \( f(a) - \alpha \), multifractal spectrum can also be described by the parameter \( D_q = \alpha \) from the perspective of information theory [40].

In \( D_q - \alpha \) representation method, \( q \) order (power parameter, referred to as power parameter) is first introduced, namely, multiply both sides of formula (12) times \( q \), and sum both sides respectively, so as to obtain:

\[
\sum_{i} p_i^q = \sum_{i} (a)^{\alpha q} = X(q).
\]

Partition function \( M \) is defined as:

\[
M(e, q) = \sum_{i} p_i^q(e),
\]

where, \( q \in (-\infty, +\infty) \) is the order of the partition function, which represents the quantity used to measure the degree of non-uniformity in the multifractal spectrum. For a certain \( q \) value, if \( M(e, q) \propto e^{a(q)} \) is satisfied, \( \alpha(q) \) at this time is called quality exponential function, which is a characteristic function used to characterize fractal behavior. For \( \alpha(q) \), the moment characteristics of sequence increments can be used to describe the characteristics of different degrees of increments, and then the fractal characteristics at different time points can be described respectively. If \( \alpha(q) \) is a straight line and the slope of the straight line is a constant, it means that the object studied is single fractal. If \( \alpha(q) \) is a segmented curve with different slopes in different elements and a convex function, it indicates that the object studied has a multifractal structure. In addition, the degree of nonlinearity of \( \alpha(q) \) graph is directly proportional to the strength of multifractal. This relation can not only describe the multifractal spectrum, but also be one of the important indicators to judge whether the research object can perform multiple analysis. Therefore, in the study of multifractal characteristics of earthquakes in the Eurasian seismic belt, it is necessary to judge whether the earthquakes in the seismic belt have multifractal characteristics in time and space series by \( \alpha(q) \).

Then, for the information dimension \( D_q \) of \( q \) order, it can be expressed by formula (16),

\[
D_q = \lim_{l \to 0} \frac{1}{q-1} \ln X(q) = D(q).
\]

Then, for the information dimension \( \alpha - \alpha \) of \( D_q - q \) order, it can be expressed by formula (16):

\[
D_q = \frac{1}{q-1} [qa - f(a)],
\]

or \( f(a) = qa - \alpha(q) \), where \( \alpha(q) = (q - 1)D_q \)

\[
\alpha(q) = \frac{d^2r(q)}{dq} = \frac{d(q - 1)D_q}{dq}.
\]

Formula (18) can be used to calculate \( D_q \) of the study area, which is also a widely used method in the study of multifractals. If \( q = 0 \), it means that the capacity dimension obtained by analysis is \( D_0 \) and \( D_0 = f(a(0)) = \alpha(0) \). If \( q \neq 0 \) and \( D_0 = f(a(1)) = \alpha(1) \) represent information dimension and if \( q \gg 1 \), it plays a decisive role in the sum of \( \sum_{i=1}^{N} p_i^q(e) \). At this time, \( M(e, q) \) and \( \alpha(q) \) reflect the nature of the dense area with high probability of seismic activity in the Eurasian seismic belt. If \( q \ll 1 \), it plays a less decisive role in the summation of \( \sum_{i=1}^{N} p_i^q(e) \) then \( M(e, q) \) and \( \alpha(q) \) both represent the nature of sparse areas with a low probability of seismic activity in this seismic belt. Through the aforementioned method, the multifractals of the object of study can be described from two different aspects, thus simplifying a complicated process to study the singularity of different regions.

At present, based on a large number of seismic data in history, the results show that earthquakes have aggregation characteristics similar to fractal structure, and when using the multifractal analysis to study the phenomenon of earthquake aggregation, a meaningful breakthrough point can be found. In addition, the famous Kurt’s law also points out that there is a power–law relationship between the energy released by an earthquake and its frequency after the study of seismic data, which indicates that the distribution of seismic activity is scale invariant. Therefore, the multifractal theory can be used to describe the multifractal characteristics of seismic activity well.
4 Multifractal characteristics of seismic time in Eurasian seismic belt

In the study of multifractals, the sample size directly affects the final result of analysis, so the sample size should be considered as an important influencing factor first. The results of the predecessors show that when the data ratio is 200 h, the dimension of multifractals will have different pseudo-multifractals with different power parameters. When the amount of data is much larger than 200, the results can objectively and truly present the essential characteristics of the research object. In this study, \( M \geq 4.5 \) seismic data were selected from the pre-processed seismic activity data of the Eurasian seismic belt, and there were 50,657 seismic data, far more than 200. Therefore, multiple analyses can be performed.

4.1 Choice of power parameters \( q \)

Since the selection of power parameters \( q \) directly affects the display of the distinguishing dimension of the study, its selection is very important. Theoretically, the range of values of the parameter \( q \) is the entire set of real numbers \([-\infty, +\infty]\), and the larger the range, the more the fractal dimension changes. However, in actual application, as the power parameter \( q \) value gradually increases, the amount of computation required increases rapidly in the form of power exponent large, the calculation result will overflow and report an error termination, and eventually the multifractals graphics cannot be obtained. Conversely, if the range of values of the power parameter \( q \) is too small, the amplitude fluctuation \( f(\alpha) \) will be very large, making it difficult to visually represent the multifractal characteristics of the research object. In addition, if the value of \( q \) is taken too small, then we obtain only the fractal spectrum in the range of power parameters, not the complete multifractal spectrum for the entire study area, and this will make a lot of necessary and real information will be lost, making it difficult to obtain a full picture of the multifractal properties of the study area.

Therefore, when multifractal analysis is used to analyze the time series of earthquakes in the Eurasian seismic belt, the original seismic data are combined and empirical value, after repeated experiments, the value range of \( q \) was finally determined to \([-10, 10]\), and gradually increase within this interval taking \( \Delta q = 0.1 \) as increments. In this range, the obtained multifractal spectral curve \( f(\alpha) \) is similar to the variation characteristics of the range \( q \in (-\infty, +\infty) \). Such value analysis can not only plot the multifractal spectral curve of the time series of seismic activity in the seismic zone but also greatly reduce the amount of calculation.

**Figure 3:** Time interval of earthquakes in the Eurasian seismic belt.
4.2 Seismic sequence diagram of Eurasian seismic belt

For playing the multifractal analysis on time series for earthquakes in the Eurasian seismic belt, the seismic catalog of the seismic belt should be displayed on the timeline first, and then the change information of the time interval between two adjacent earthquakes \((M \geq 7)\) should be analyzed to obtain the seismic time interval sequence diagram of the seismic belt. (as shown in Figure 3). The study area interval sequence diagram clearly, on the whole, shows the Eurasian seismic belt of earthquake activities from 1900 to 2022 years, and the time interval is not average, with the largest interval being more than 1,400 days and the smallest being 0 day. Earthquakes with long intervals tend to be preceded by a period of high incidence for a period of time, which indicates that earthquakes occur more frequently in concentrated periods. Locally, among the years 1915–1919, 1957–1961, 1971–1975, and 2016–2020, large earthquakes occur at relatively large intervals, indicating a lower number of major earthquakes during this period, i.e., sparse activity. The relatively short-time interval indicates that the earthquake is active at this stage. If the interval time is large, it indicates that the more energy the earthquake accumulates, the more energy it releases, and the interval time after the earthquake will shorten, indicating that the release of earthquake energy slows down, which can also be said to gather energy for the outbreak of the next earthquake. In conclusion, it can be seen from the time interval sequence diagram of earthquakes in the whole Eurasian seismic belt that, with the passage of time, there are great differences in the time interval variation and time intensity of two adjacent earthquakes.

In the study of the tectonic movement of the earth, the internal stress of the earth and a series of aftershocks, it is often necessary to conduct statistical analysis of the energy released by earthquakes in the study area. The most direct expression of the destructiveness and strength of seismic activity is the release of energy in the earthquake, and it also implies the transmissibility of seismic energy, which may contain the information that the upcoming or future major earthquake is gestation. In addition, it plays an important role in earthquake prediction to study the temporal and spatial variation of energy released during the seismic activity. Therefore, the study of the energy released by earthquakes is also a key factor affecting the seismic activity.

The estimation formula of earthquake energy release is expressed as follows:

\[
E = \Omega = 10^{1.5M - c},
\]

where \(M\) is the magnitude of the earthquake and \(c\) is a constant. Its value is generally obtained based on the studies of predecessors, and it is usually taken as an empirical value of 4.8.

4.3 Multifractal spectrum analysis

Based on the aforementioned basic principles, multiple analysis and calculation of the time series of seismic activity in the Eurasian seismic belt were carried out, and the value of logarithm under different values was obtained (Figure 4). When \(q > 4\) was found in the experiment, the linear relationship in the \(\ln X(q) - \ln L\) diagram of the study area was not very good. Therefore, to facilitate comparative analysis, only those within the range of \(q \in [-4, 4]\) are shown in Figure 4, and the \(\ln X(q) - \ln L\) diagram of earthquakes in this seismic zone is calculated by taking 0.5 as the step length. Where, \(X(q)\) is the partition function, refers to the sum of the \(q\) power of the corresponding probability distribution set after the earthquake in the seismic belt is fitted on the time series, and each power parameter \(q\) value corresponds to a curve.

It can be seen from Figure 4, regardless of the power that \(q\) value is less than zero or greater than zero. \(L\) interval obtained \(\ln X(q)\) curve with the change of \(\ln L\) presents a good linear relationship, and the linear relationship is stronger, and it shows that the seismic zone seismic activity on the time scale of multifractal characteristics and this feature is obvious. In addition, when the value of the power parameter \(q\) is greater than 0, \(\ln X(q)\) changes and increases gradually with \(\ln L\) starting from

![Figure 4: \(\ln X(q) - \ln L\) diagram of time series of the Eurasian seismic belt.](image-url)
–10, basically presenting a straight line with a positive slope. When power cords $q$ value is less than zero, the value of $\ln L$ in the process of the calculation is too small, i.e., the time axis of earthquake activities can be divided into a series of fine time. Every time the probability of it get on the seismic data in their respective corresponding timeline is very small, small probability events tend to be ignored, or the overall impact is not big. In this case, $X(q) = 0$, Therefore, the value of $\ln X(q)$ will be evaluated from $\ln L = -4$, and the resulting value of $\ln X(q)$ will be obtained. Outliers appear in $\ln X(q)$ values and are shown in Figure 4 as approximate lines with a negative slope. In fact, even if the calculation accuracy can show the small probability event of abandonment, when the power parameter is less than 0, the value of $\ln L$ itself will be relatively small, and the corresponding $\ln X(q)$ value will be far greater than 25. In addition, with the increase of $\ln L$, $\ln X(q)$ will sharply decrease, so that there will be an abnormal decline of the approximate straight–line curve. This indicates that not all data in the RRR range have scale invariance during this process.

The logarithmic graph $\ln X(q) - \ln L$ corresponding to the values of different power parameter $q$ in the study area is obtained, which not only proves that the earthquake in this seismic zone has multifractal structure in time series but also obtains the mass function $\tau(q)$ according to the curve, which is the slope of the curve.

The conversion relationship between the quality function $\tau(q)$ and the partition function $X(q)$ is expressed as follows:

$$\tau(q) = \lim_{L \to 0} \frac{\ln X(q)}{\ln L}. $$

(21)

As can be seen from the aforementioned equation, in theory, you need to perform the limit operation to obtain the mass function $\tau(q)$. However, in practice, due to the limitation of sample space, it is impossible for limit operation to occur in the calculation process of $\tau(q)$. Therefore, in the calculation of $\tau(q)$, the logarithmic graph of $\ln X(q) - \ln L$ is obtained according to the power parameter $q$, and then the curves corresponding to the $q$ values of different power parameters are fitted by the unary linear regression method, thus the corresponding data can be calculated, and the calculation formula is obtained as follows:

$$\ln X(q) = a + bL. $$

(22)

Then, $\tau(q)$ can be obtained from the calculated slope of the line, namely:

$$\tau(q) = |b|. $$

(23)

Finally, the distribution diagram of its power parameter values is obtained (see Figure 5(a)). It can be seen from Figure 5(a) that this characteristic function is obviously not a straight line, which indicates that earthquakes in this seismic zone have strong multifractal characteristics in time series. Different values of $q$ quality of the corresponding function $\tau(q)$ correspond to different fluctuations, and it shows the different magnitude of earthquakes with different wave information, and the scale of values changes over time. At different time scales, seismic information with volatility fluctuation changes and different time scales of the multifractal characteristics of seismic activity are obtained. In addition, the slope of the curve in the $\tau(q) - q$ diagram can be roughly divided into two parts, and the slope of the former part is larger than the latter, which indicates that the earthquakes in this seismic zone have the characteristics of multifractal in time series. In addition, as the difference between the slope of curves in different time periods in Figure 5 is positively proportional.

**Figure 5:** Time series relationship of the Eurasian seismic belt. (a) $\tau(q) - q$ relationship of time series of the Eurasian seismic belt. (b) $D_q - q$ diagram of seismic time series in the Eurasia seismic belt. (c) $f(q) - \alpha$ relation of time series of the Eurasian seismic belt.
to the strength of the corresponding multifractal degree, it can be seen from Figure 5 that the difference between the slope of the front and the back sections is large, which indicates that the former period has strong multifractal characteristics, while the latter period has weak multifractal characteristics. On the whole, the nonlinear of the whole curve is strong, which indicates that the study area has the characteristics of multifractals, and its degree is strong.

Although the time series of seismic activity in this seismic belt has the characteristics of multifractals, it is difficult to obtain more detailed intensity of multifractals of seismic activity in this seismic belt. To describe the seismic belt earthquakes on the time series of the extent of the multifractal strength, based on the analysis of the earthquakes on the seismic belt after the time sequence of \( \ln x(q) - \ln L \) and \( r(q) - q \) relations, also can get two kinds of multifractal spectrum analysis to the earthquakes on the time series of multifractal characteristics is described.

First, the \( D_q - q \) relationship of seismic activity time series in this seismic belt is analyzed and studied. According to formulas (3) and (4) in the multifractal theory, the \( D_q - q \) diagram of the time series of seismic activity in this seismic zone can be calculated (Figure 5(b)):

As can be seen in Figure 5, the curve is a nonlinear subtraction function, and different \( q \) values \( D_q \) represent the characteristics of the dense and sparse parts of the observation, respectively. In the processing of the power parameter \( q \) values gradually change from negative to zero and then increase to positive values, the smaller \( P \) value plays a major role gradually transition to the larger \( P \) value plays a major role, i.e., the time series of seismic activity in the seismic belt gradually transitions from describing the complexity degree of the sample structure of the sparse zone to the complexity degree of describing the structure of the cluster region. In the sparse region, \( D_q - q \) curve changes gradually increase with the increase of \( q \) value, and \( D_{\infty} \) increases correspondingly, while \( D_{\infty} \) decreases correspondingly. In addition, \( D_{\infty} \) decreases significantly with time and energy changes in the study area before large earthquakes, which is a good predictor of the occurrence of large earthquakes. However, because the seismic zone involves a wide range of spatial locations, the singularity in the local small range may be weakened, or even ignored, which is the reason why this phenomenon is not particularly obvious in the \( D_q - q \) diagram of the earthquake in this seismic zone time series.

In addition, the complexity of the seismic belt can be expressed according to the dynamic characteristics of the \( D_q - q \) curve of seismic activity in time series. In general, if the \( D_q - q \) curve shows slow deformation, that is, \( D_q \) decreases slowly with the increase of \( q \), it indicates that the earthquakes in this seismic zone are not particularly complicated. On the contrary, if its \( D_q - q \) curve shows steep deformation, that is, it drops sharply in \( q \) with the increase of \( D_q \), it indicates that the earthquakes in this seismic zone are particularly complicated. The \( D_q - q \) diagram of seismic time series in the Eurasian seismic belt shows that the \( D_q \) have a sharply decreases before a slowly decreasing, \( D_0 = 1.55 \). This phenomenon is probably caused by the uneven distribution of released energy of the seismic belt to each region, which leads to a higher complexity of the multifractal. This indicates that the time series of seismic activity in the seismic belt is highly complex, which is consistent with the complexity of the geographical structure.

The seismic zone is located in a very complex geological structure and geographical environment. In the process of seismic energy release, the capacity dimension and information dimension of the single fractal can describe its temporal and spatial variation to a certain extent when analyzing its seismic variation characteristics. However, in a double-logarithmic plot of seismic time series distribution, its nonlinearity is strong in the scale-free region. For showing the characterization of seismic time series objectively, multifractal analysis of the seismic time series of the Eurasian seismic belt, and the \( D_q - q \) diagram of it was obtained after calculation. It can reflect the difference between clustering region and sparse region in the multifractal structure to some extent, but the effect is not as good as shown in \( f(a) - a \) diagram. \( f(a) - a \) curve can only represent the singularity of the energy released during seismic activity in time series but also quantitatively describe its characteristics through the multifractal spectrum. Therefore, the scale index spectrum \( f(a) - a \) relation can be used to describe the heterogeneous complex fractal characteristics.

According to the form of the \( f(a) - a \) diagram, its curve types can be roughly divided into the following categories: sparse type, with the vertex deviating to the left; intensive, vertices biased to the right. The left part of the curve represents the cluster area of earthquakes in this seismic belt during the time period, and the right half of the curve represents the sparse area of earthquakes in this seismic belt.

According to the \( f(a) - a \) curve of earthquakes in this seismic zone in time series (Figure 5(c)), this curve is characterized by sparse multifractal, and its vertex is tilted to the left. It is a continuously smooth curve with asymmetry. There is a large difference between the shape of the front part and the shape of the back part of the curve, that is, \( a_{\min} \) is small, which indicates that the clustering characteristics of earthquake intensity in the time
series of these two periods are similar. Peak as the cut-off point, on the left side of the cut-off point, represents the sparse seismic area, and that on the right represents the seismic cluster area of sparse of unbounded, that is, on the left side of the vertex, does not exist an exact $\alpha$ value, suggesting that the intensity distribution of the seismic time series on the Eurasian seismic zone is only cluster and the infinite cluster.

In addition, it can be seen from Figure 5(c) that the vertex of the curve is biased to the left, which indicates that the clustering of earthquakes in the time series in this seismic zone has a high frequency and probability. Therefore, it can be said that the earthquakes on the time series cluster as its major characteristics, but there is a difference between two stages before and after, which shows that in the previous period, earthquake activity of small earthquakes cluster dominated, and then segment is more uniform. The cause of this result and the geological structure of the ring has a lot to do.

5 Multifractal seismic spatial characteristics of Eurasian seismic belt

The multifractal analysis of the spatial distribution series of the Eurasian seismic belt is similar to that of the time series, but the difference between them is that the data on the spatial distribution series need grid preprocessing first.

Seismic data can be spatially expressed in terms of latitude and longitude as well as depth. In this way, it is presented in three dimensions. To facilitate its analysis, the depth attribute is not considered here, and the multifractal analysis of its spatial characteristics is carried out on the plane. The steps are as follows: First, the study area is divided into grids according to different spatial attributes. Then, the attribute information in each unit after discretization is counted. Then, the seismic energy in each grid is calculated and analyzed. Finally, the multifractal spectrum of the spatial distribution sequence of earthquakes in the seismic belt can be obtained.

5.1 Grid of earthquakes in the Eurasian seismic belt

After the grid processing of the study area is completed and the seismic information in each grid cell is obtained, the total energy released by the earthquake contained in each grid cell can be calculated according to formula (24). The aforementioned steps are the data preprocessing of multifractal analysis on the spatial distribution sequence of the earthquake in the seismic belt. On this basis, the dimension and singular spectrum of the multifractal spectrum can be obtained and analyzed. The grid statistics of the energy released by earthquakes in this seismic zone can be expressed as follows:

$$E = \begin{bmatrix}
    E_{11} & E_{12} & \cdots & E_{1n} \\
    E_{21} & E_{22} & \cdots & E_{2n} \\
    \vdots & \vdots & \ddots & \vdots \\
    E_{m1} & E_{m2} & \cdots & E_{mn}
\end{bmatrix},$$

where $E$ represents the energy matrix, where represents the total energy released by the earthquake in this seismic zone, and $E_{mn}$ represents the total energy released in the cell of row $m$ and column $n$ in grid.

5.2 Multifractal spectrum analysis

On this basis, similar to its multiple analysis on time series, its spatial relation diagram can be obtained by taking the power parameter and taking 0.5 as the step length (Figure 6).

Figure 6 shows that, similar to the multiple analysis results in time series, in space, no matter the power parameter is less than 0 or greater than 0, all the curves of $X(q) \ln L$ show a good linear relationship with $\ln L$, which indicates that the earthquakes in this seismic zone have the characteristics of multifractal in spatial distribution sequence. All curves in the graph can be roughly divided into two parts from the point of view of the slope of
segments, which not only shows the characteristics of multifractal but also shows the strength of multifractal characteristics. In addition, when the value of the power parameter \( q \) is greater than 0, \( \ln X(q) \) changes and increases gradually with \( \ln L \) starting from –10, basically presenting a positive straight line. When the power parameter \( q \) is greater than 0, the values of \( \ln L \) are too small, i.e., the spatial distribution of the seismic been divided into more of segments, the occurrence probability of the seismic data of each grid is pretty small, the small probability events could be ignored, and here \( X(q) = 0 \). Therefore, the value of \( \ln X(q) \) will be evaluated from \( \ln L = -4 \) and the value of \( \ln X(q) \) will change accordingly. The outliers appear in the \( \ln X(q) \) value and are shown in the graph as the approximate lines with negative slope. In fact, even if the calculation accuracy can show the small probability event of abandonment, when the power parameter is less than 0, the value of \( \ln X(q) \) itself will be relatively small, and the corresponding \( \ln X(q) \) value will be far greater than 25. Moreover, as \( \ln L \) increases, \( \ln X(q) \) will decrease sharply, and there will also be a curve similar to a straight line with abnormal decline. This indicates that not all data in \( L \) range have scale invariance in this process.

In addition, compared with the \( \ln X(q) - \ln L \) diagram of time series, in the \( \ln X(q) - \ln L \) diagram of spatial distribution sequence, when the power parameter is gradually larger than 4, the linearity of the obtained curve will gradually become less obvious and there will be more obvious fluctuations. This phenomenon mainly caused by the fact that when meshing, with the decrease of \( L \) the amount of data in each grid drops sharply, eventually making its multifractal characteristics incomplete.

\( \tau(q) \) can also be calculated according to the slope of \( \ln X(q) - \ln L \) curve, and \( \tau(q) - q \) can be analyzed and studied after the logarithmic graphs corresponding to different power parameters of seismic activity in this seismic zone are obtained.

Instead of time series analysis of the multiple similar, according to the first power value and \( q \), its space sequence is drawn on the \( \ln X(q) - \ln L \) log–log graph, according to different powers and its corresponding \( q \) value curve by the monadic linear regression method for fitting, respectively, and the corresponding data are calculated and according to the scope of power parameter values for each linear fitting a curve. Finally, the \( \tau(q) \) value was calculated, and the \( \tau(q) - q \) relation comparison diagram (Figure 7(a)) was obtained on the basis of the spatial distribution sequence of the earthquakes in the seismic belt. It can be seen from Figure 7 that the slope of the curve is constantly changing, which generally increases first and then decreases, indicating that the seismic energy does have the characteristics of multifractal in the spatial sequence. On the whole, the nonlinear of the whole curve is strong, which indicates that the seismic activity in this seismic belt is of strong degree of multifractal in space, which is consistent with the result of multiple analysis in time series.

In addition, the time series with the \( \tau(q) - q \) contrast diagram can be found that the \( \tau(q) - q \) space sequence diagram in two stages before and after the change is more apparent, nonlinear, and more obvious. The earthquake activity of the seismic zone is shown. When the space sequence set is compared with the time series set, the complexity is relatively high, and its multifractal characteristics are more obvious.

To do better in describing the ring in the spatial distribution of the earthquake sequence on the extent of the

![Figure 7](image)

**Figure 7:** Comparison of spatial distribution sequence relation of seismic activity in the Eurasian seismic belt. (a) Comparison diagram of \( \tau(q) - q \) relation of spatial distribution sequence of seismic activity in the Eurasian seismic belt; (b) spatial distribution sequence \( D_q - q \) of seismic activity in the Eurasian seismic belt; (c) \( f(a) - a \) relation diagram of seismic activity spatial distribution series in the Eurasian seismic belt.
multifractal strength, in the analysis of the spatial distribution of the seismic sequence of \( \ln X(q) - \ln L \) diagram and \( \tau(q) - q \) diagram, two kinds of multifractal spectrum analyses of the seismic on the time series of multifractal characteristics are described.

First, for the relationship diagram of \( D_q - q \) in the spatial distribution sequence of earthquakes in this seismic belt, the \( D_q - q \) diagram of the spatial sequence of seismic activity in this seismic belt was calculated according to formulas (3) and (4) in the multifractal theory (Figure 7(b)). In Figure 7, power and \( q \) values increases from the negative to zero gradually in the process of adding positive, and smaller \( P_i \) value plays a major role and it gradually transitions to the larger \( P_i \) value that plays a major role, namely, the seismic space sequence by describing the complexity of the sparse sample structure gradually transitions to describe the complexity of the structure of the cluster region. In the sparse region, \( D_q - q \) curve changes gradually, \( D_\infty \) increases correspondingly, while \( D_\infty \) decreases correspondingly. In addition, \( D_\infty \) generally has an obvious decrease before the big earthquake with the change of time and energy in the study area, which is a good omen before the occurrence of the big earthquake. However, because the seismic zone involves a wide range of spatial locations, the singularity in the local small range may be weakened or even ignored, which is the reason why this phenomenon is not particularly obvious in the \( D_q - q \) diagram of the spatial distribution sequence of earthquakes in this seismic zone.

In addition, according to the dynamic characteristics of \( D_q - q \) curve of seismic activity in spatial sequence, the complexity of the seismic belt can be expressed. In general, if the \( D_q - q \) curve shows slow deformation, that is, \( D_q \) decreases slowly with the increase of \( q \), it indicates that the earthquakes in this seismic zone are not particularly complicated. On the contrary, if the \( D_q - q \) curve presents a phenomenon of steep deformation, that is, \( q \) decreases sharply with the increase of \( D_q \), and it indicates that the earthquake in this seismic zone is particularly complicated. The seismic zone in the spatial distribution of the earthquake sequence in the \( D_q - q \) diagram shows that the seismic zone in the spatial distribution of the earthquake sequence \( D_q - q \) figure on the first sharply reduced, and then slowly decreased, and \( D_0 = 1.52 \). This kind of phenomenon is likely to be due to the seismic zone caused by various stress-release energy that is not evenly distributed to each area. Therefore, the complexity of multifractal is high, which indicates that the time series of seismic activity in this seismic belt is highly complex, which is consistent with the complexity of the geographical structure and can better reflect the multifractal characteristics of its spatial distribution sequence.

These conclusions are consistent with the \( D_q - q \) diagram of time series, which indicates that the seismic activity in this seismic zone is highly complicated due to the uneven energy release. It also shows that the energy release of the seismic zone is a complex process, which is consistent with its geological structure background.

The \( f(\alpha) - \alpha \) relation diagram of the spatial sequence of the seismic zone (Figure 7(c)) can also well characterize the characteristics of multifractals.

As shown in Figure 7, the curve is characterized by sparse multifractals, and its vertices deviate to the left. It is a continuous smooth curve with asymmetry. There is a large difference between the shape of the front part and the shape of the back part of the curve, that is, \( a_{\text{min}} \) is small, which indicates that the clustering characteristics of earthquake intensity in the time series of these two periods are similar. Taking the peak as the cut-off point, the left side of the peak point represents the sparse seismic region, while the right side represents the seismic cluster area, there is no an exactly value of \( a \) on the left side, which indicates that the intensity distribution of seismic in the Eurasian seismic belt on the time series is only infinite cluster. This is consistent with the conclusion of \( f(\alpha) - \alpha \) diagram of time series.

In addition, Figure 7 shows that the vertex of the curve is left, which indicates that the occurrence frequency and probability of clustering in the spatial distribution sequence of earthquakes in this seismic belt are high. Therefore, it can be said that the ring in the spatial distribution of the earthquake sequence on the cluster as its main feature. However, the difference between the two stages before and after the peak shows that in the previous period the cluster of the small earthquakes dominated, and the later segment is more uniform, it has a great relation to the geological structure of the seismic belt.

As can be seen from the \( \alpha \) curve and \( a(0) \) (Figure 8), when \( q \) is negative, the singularity index of the corresponding earthquake in this seismic zone exists in a larger range, which indicates that the spatial distribution of earthquake intensity in this seismic zone is infinite and sparse. If \( q \) is positive, and the seismic belt of the existence of the singular index of earthquake area is larger, this indicates that the earthquake intensity on the spatial distribution of seismic zone shows the characteristics of the infinite cluster, which can explain the spatial distribution of the multifractal characteristics of obvious differences, with the \( f(\alpha) - \alpha \) sequence in the space relationship between the conclusion being consistent.
6 Analysis and discussion

In the study of earthquake precursors, the randomness and complexity of seismic activity affect the accuracy of predictions. Among the various natural phenomena, earthquakes are generally regarded as a natural phenomenon with the characteristics of scale invariance. It is possible to perform statistical analysis of the phenomenon using fractal statistical principles, indicating that the phenomenon is a random self-organizing critical process. The theory of multiple fractals has been continuously deepened and popularized in the application of earthquakes, and its theory has gradually developed with perfection [50–53]. If this theory can be applied to the study of the spatiotemporal propagation characteristics of earthquakes, better regularity of seismic activity can be obtained, which will promote the development of earthquake prediction and forecasting.

In this study, it is found that the earthquakes in the seismic zone have the characteristics of self-similarity and multifractals in the spatiotemporal sequence. The nonlinearity and difference of the space–time sequence in the scale-free region of the seismic zone not only indicates the complexity of the fractal structure on its space-time sequence but also shows its characteristics of multifractals [54]. Therefore, analyzing it using multifractal analysis can provide a good characterization of its behavior in space–time. The multifractal characterization of seismic spatiotemporal distribution sequence was described by the relationships of $\tau(q) - q$, $D_q - q$, and $f(\alpha) - \alpha$, and indicate the sparse category of the multifractal characterization according to the important parameters of respectively relationship, and the causes of this property are analyzed. These conclusions not only show that the spatiotemporal propagation of earthquakes is regular but also show that there is a close relationship between them and geological structures.

The main contributions of this article are as follows:

1. In $X(q) - \ln L$ maps of the seismic spatio-temporal series of the Eurasian seismic belt all show that it has the characteristics of multifractal in the spatio-temporal series and is obvious. This provides a new perspective and ideas for the further study of the law and mechanism of seismic activity.

2. The $\tau(q) - q$ curve of the seismic spatio-temporal series of the seismic belt shows that the energy released by the earthquake has the characteristics of multifractal in the spatio-temporal series and is obvious. It can describe the spatial and temporal evolution process of earthquake sequence more accurately, so as to improve the accuracy and reliability of earthquake prediction and risk assessment.

3. The singular spectrum $f(\alpha)$ of the earthquake in the temporal and spatial series of the seismic belt is an asymmetric continuous smooth sparse curve, and the $f(\alpha) - \alpha$ curves of the two sections are obviously different, and the $a_{\text{min}}$ is relatively small, which indicates that the clustering characteristics of the earthquake activity intensity in the temporal and spatial series of the seismic belt are similar. By analyzing the temporal and spatial sequence of seismic activity in seismic zones, this study found that it is clustered, which is important for further studying the spatial distribution law and mechanism of seismic activity.

4. According to the $a_{\text{min}}$ value of the earthquake in this seismic zone, the left branch of the multifractal spectrum of its spatio-temporal sequence is not convergent, which indicates that the spatial and temporal distribution of its activity intensity is almost clumping, infinite clumping.

5. $\Delta f = f(a_{\text{min}}) - f(a_{\text{max}})$ is defined, which can reflect the concentration degree of energy released by seismic activities in the seismic zone to a certain extent. This provides a new method and idea for further studying the spatial distribution law and mechanism of seismic activity. When this parameter is greater than 0, it indicates that the energy released by the earthquake is concentrated strongly, and vice versa. The $\Delta f$ of earthquakes in this seismic zone is greater than 0, which indicates that the probability of energy accumulation released by earthquakes in this seismic zone is greater.

![Figure 8](image-url) 

Figure 8: $\alpha$ curve and $\alpha(0)$ value of the Eurasian seismic belt.
7 Conclusion

In this article, based on the basic principle of multifractal analysis, the time–space sequence of earthquakes in the Eurasian seismic belt was analyzed. The most suitable power parameters were determined through many experiments and the multifractal spectrum curves of the energy released by earthquakes in the time and space series are obtained from different angles. On the basis of this, it is found that the earthquakes in this seismic zone have complex multifractal characteristics in time and space series, and the causes of this characteristic are analyzed. Results showed that the seismic zones of seismic activity in time series and spatial scales have obvious multifractal structure of complex, that is to say, study the seismic activity of the seismic zones using multifractal analysis can reveal the seismic characteristics in in time and space series well, and also can effectively reveal the basic law of seismic activity. Thus, it lays a theoretical foundation for earthquake prevention and control in this seismic zone. Due to the limitations of geophysics, geology and mathematics, and seismic sample data recording, this article still has many shortcomings, and it needs to address how to better improve the model and the design of multifractals. More accurate algorithms to process sets with larger sample sizes, multifractal analysis, and the conception of a more reasonable and accurate spatial distribution fractal model should be the direction of further research.

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