Spatio-Temporal Distribution of Earthquake Disasters in Qinghai Province of China Based on GIS

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Abstract. Qinghai Province is located in the northwest part of China, is part of Qinghai-Tibet Plateau, its special location, abnormal climate, is the frequent occurrence of earthquake disaster area. Under the background of global climate change, earthquake disaster research in Qinghai province is of great significance for ecological protection and disaster prevention. In this paper, the data of earthquake disaster with M_S ≥ 5 in Qinghai Province from 1960 to 2022 are collected statistically, and the risk grade distribution map of earthquake disaster is made by using GIS technology with the county and city as the unit. The spatial and temporal distribution law of earthquake disaster is illustrated from the distribution of earthquakes over the years and the annual occurrence frequency. The results show that the earthquake disasters in Qinghai Province are mainly concentrated in the northwest and southwest areas, the central and northern areas are also relatively high distribution, among which Geermu city and Yushu City are more affected. In terms of time, earthquake disasters occurred frequently from 1990 to 2010, and the frequency of disasters decreased slightly from 2010 to 2020, but in the past two years, the geological activity is more frequent, and the disaster incidence is high.

1. Introduction

Under the background of climate change led by global warming, the climate all over the world has presented an unstable situation, and the frequency of extreme weather has increased. In recent years, the frequency and scale of natural disasters are increasing and expanding. Take China as an example. In 2022, the country experienced many types of natural disasters, such as flood disasters, drought disasters, forest fires, hail and lightning disasters caused by strong convection weather, cold rain and snow freezing disasters, and earthquakes. The overall performance is high incidence in summer, and the central and western regions are seriously affected.

The reason why natural disasters attract people's attention is that their occurrence usually causes relatively serious economic losses, and their losses and impacts also show a rising trend in recent years under the environmental changes. For example, earthquake, rainstorm, drought and other natural disasters with large impact scope and deep impact usually cause direct economic losses to the place where they occur, which are specifically manifested in land and building damage. Secondly, such disasters will also cause large and lasting economic losses to the planting industry and animal husbandry, which is extremely unfavorable to local development and economic construction. In addition, some secondary disasters, such as floods, landslides and debris flows, have not only caused economic losses, but also seriously affected the local ecology. In the absence of human intervention, the ecological recovery time of some areas after disasters may even be as long as hundreds of years. This is undoubtedly a violent impact on ecologically fragile regions, and such a vicious cycle will seriously damage local ecological construction, causing irreversible and immeasurable losses.

Earthquake disaster is one of the most threatening natural disasters to human beings. In many affected areas, Qinghai Province is a typical area where earthquake disaster occurs because of its special geographical position and climatic conditions. Therefore, it is urgent to study the temporal and spatial distribution characteristics of earthquake disasters in Qinghai Province. It is of great significance to have an in-depth understanding of the evolution trend and spatial distribution law of earthquake disaster occurrence frequency for rapid identification and evaluation of earthquake emergency disaster.

2. Study area and methods

2.1. Study area

Qinghai Province is a provincial administrative region of our country, located in the northwest inland, between
east longitude of 89°24 '3' to 103°4 '10 ", north latitude of 31°36' 2 'to 39°12' 45 ", the length of east and west is 1240.6 km, and north and south is 844.5 km as shown in Figure 1. The overall topography of Qinghai province is high in the west and low in the east, high in the north and low in the middle, high in the west, sloping to the east and descending in the form of a ladder, and the eastern part is a transition zone from the Qinghai-Tibet Plateau to the Loess Plateau, with complex topography and diverse landforms. Mountains form the basic skeleton of the province's landform. The province's average altitude is higher, at more than 3000 meters.

2.2. Methods

At present, there are a lot of research methods on earthquake disasters, and most of them are based on spatial remote sensing technology and GIS to classify the risk of disasters within a certain time and space, so as to evaluate the disaster risk, so as to play a role in prevention and warning. By referring to the Statistical Yearbook of Qinghai Province and the situation database of Qinghai Province, collecting and searching the County Annals of Qinghai Province and other relevant statistical data. The data collected mainly focused on the frequency of earthquake disasters (MS≥5) in Qinghai Province during 1960-2022. Firstly, spatial statistics was used to analyze the occurrence frequency of earthquake disasters in different years in Qinghai Province in time dimension, taking 10a as the statistical unit, so as to obtain the evolution trend of the occurrence frequency of earthquake disasters in different years. Finally, ArcGIS 10.2 software was used to analyze the spatial variation characteristics of the frequency of earthquake disasters in Qinghai Province, so as to obtain the temporal and spatial distribution rules of earthquake disasters in Qinghai Province.

3. Results

3.1. Time distribution of earthquake disasters

All earthquake disasters (MS≥5) occurring in Qinghai Province during 1960-2022 are shown in Figure 2. It can be seen that the frequency of geological activities in Qinghai Province was relatively low before 1980, with only 5 earthquakes recorded in the 1960s and 7 earthquakes recorded in the 1970s. Of course, this is not taking into account the relevant technical conditions of the last century is not perfect, the earthquake statistics may be lost.

So we focused on the seismic record after 1980. As shown in Figure 2, from 1980 to 2010, the number of earthquake disasters occurred in every 10 years was 13, 21, and 38 successively, showing an obvious rising trend, which indicates that seismic activities in Qinghai Province were relatively frequent in these 30 years, and reached a high level in 2000-2010, accounting for 33% of the statistical times. The 7.1-magnitude Yushu earthquake (which occurred in April 2010) caused huge damage and economic losses was in this time period. Considering the Wenchuan earthquake which occurred outside Qinghai Province but also at the eastern edge of the Qinghai-Tibet Plateau in 2008, it can be inferred that the Qinghai-Tibet Plateau seismic belt has been relatively active and frequent earthquake disasters since 2000. Although the number of earthquakes dropped to 16 between 2010 and 2020, it is still not negligible.

In recent years, from 2020 to 2022, just two years, qinghai province is 14 times MS of 5 or more earthquake disaster, and in May 2021, Golog state, Maduo county in qinghai province has recorded the highest an earthquake of magnitude 7.4. The quake damaged several main lines and toppled two Bridges, though the region's defences and buildings have improved significantly in recent decades. Therefore, there may be multiple earthquakes in Qinghai Province in the future, and relevant departments need to strengthen prevention.
3.2. Spatial distribution of earthquake disasters

According to the earthquake frequency of each county and city in Qinghai Province during 1960-2022, the spatial distribution characteristics of earthquake risk level in Qinghai Province were analyzed, as shown in Figure 3. It can be known that the earthquake in Qinghai Province is mainly concentrated in the west, the eastern region few earthquakes. Earthquakes of magnitude 5 and above have occurred throughout the province. On the whole, Haixi Mongolian and Tibetan Autonomous Prefecture and Yushu Tibetan Autonomous Prefecture are the areas with high incidence of earthquakes in Qinghai Province. It is followed by Golog Tibetan Autonomous Prefecture, Haibei Tibetan Autonomous Prefecture and Hainan Tibetan Autonomous Prefecture. Xining area and Haidong area have the least frequency of earthquakes, so it is also a relatively developed area of Qinghai Province.

According to statistics, a total of 60 earthquake disasters with MS≥5 occurred in Haixi Tibetan Autonomous Prefecture during 1960-2022, accounting for about 50% of the total earthquake disasters in Qinghai province. Geermu, a city in Haixi Tibetan Autonomous Prefecture, has been hit hard by nearly 30 earthquakes. It is also worth noting that Yushu City, located in the Tibetan Autonomous Region of Yushu in the south of Qinghai Province, also suffered 28 earthquakes, with a high average magnitude and serious economic losses in history. Next came Delingha City, Mangya Administrative Committee, Zaduo County and Gonghe County, all of which have had about 10 cumulative earthquake disasters and are likely to have earthquakes in the future. The number of earthquakes in the remaining counties and cities is basically about 5, while the number of earthquakes in a series of counties and cities located in the southeast of Qinghai Province is generally less than 3.

According to the results of spatial distribution of earthquake disaster risk levels in Qinghai Province, it can be basically determined that the characteristics of earthquake occurrence in Qinghai Province are frequent earthquakes in the west, few earthquakes in the southeast, and the rest of Qinghai Province is in between. This statistical data did not include earthquakes of lower magnitude and repeated aftershocks, but mainly included earthquake frequency of MS≥5. Therefore, to a certain extent, this conclusion can also represent the region where the economic loss caused by the earthquake is greater.
4. Conclusions and Discussions

Earthquake is the main geological hazard in Qinghai Province. Once this kind of disaster occurs, it usually has a series of characteristics, such as wide impact, deep impact and great loss. Qinghai Province is located in the earthquake belt of the Qinghai-Tibet Plateau. There are many earthquakes of magnitude 5-6, and almost every year there are earthquakes of magnitude 6 or more. In the past decade, there have also been major earthquakes of magnitude 7.1 and 7.4, which have caused serious economic losses.

The earthquake disasters in Qinghai Province were mainly concentrated in the northwest and southwest of Qinghai Province, and were also relatively high in the central and northern parts of Qinghai Province, while the relatively less affected counties and cities in the east and southeast were relatively dense. Among them, Geermu City and Yushu were the most frequently and seriously affected, followed by Delingha City, Gonghe County, Zaduo County and Mangya City.

According to the statistics of the year of earthquake occurrence, although the magnitude of earthquake occurred in 1960~1990 is high, but the frequency is relatively low. Since 1990, seismic activity has been quite frequent. 2000-2010 was a period of concentrated earthquake disasters. Although the earthquake disaster decreased slightly in the following 10 years, in the latest statistics in 2022, only 10 earthquakes occurred in one year, which indicates that geological activities in Qinghai Province will become frequent again in recent years, with a high probability of disaster occurrence.

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References


