The Variation of Lightning Current Parameters with Altitude in Shandong Region

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Abstract. Lightning current parameters is the basis of the transmission line design and transformation essential parameters of lightning location system somewhere in shandong area ground ground lightning information lack of height of the statistical properties, not situation, the analysis of the influence of altitude on lightning parameters using global digital elevation data filled in the lightning location data in the lack of information, analysis of the lightning current parameters and the relationship between the altitude in the region. The variation of lightning current amplitude, lightning return times, ground flash density and other factors with altitude is studied, and the variation law of lightning parameters in this area with altitude is obtained. When the altitude is 1200~2000m and 2400~3200m, the number of lightning return stroke fluctuates greatly. When the altitude is from 2000 to 2800m, the number of lightning return strokes increases with the increase of altitude. With the rise of altitude, the proportion of normal lightning flashes in total lightning flashes in shandong area has a tendency to increase gradually. Due to the shortcomings of the above three kinds of observation data, we try to learn from each other to better reflect the lightning activity rule in shandong more comprehensively, accurately and effectively, and to provide certain theoretical basis and help for lightning protection and disaster reduction work, providing reference for the design and lightning protection transformation of power grid in shandong.

Keywords: Lightning Current Parameters, The Altitude, Elevation Data Model, Lightning Current Amplitude

1. Introduction
Lightning protection design of power systems depends on comprehensive and accurate statistics of lightning parameters [1]. In the early stage, lightning parameters were mostly obtained by meteorological observation, with limited range and accuracy. In recent years, the lightning location system has been widely applied in China, which greatly improves the acquisition ability of lightning parameters. Through lightning electromagnetic telemetry [2], lightning strike fault point location and lightning flow calculation have been realized, which provides a basis for the design of transmission lines and the formulation of lightning protection measures, and reduces the lightning trip rate of
transmission lines. At present, the lightning location system in China is based on GIS map [3-4], which cannot directly obtain the impact data.

Shandong region is located in the eastern coast, with the central mountains rising, the low and flat areas in the southwest, and the gentle undulating hills in the east, forming a topographic trend with mountains and hills as the framework[5] and staggered plain basins. The mountainous area is mainly distributed in central Shandong and local areas of southwest Shandong, and the main mountain ranges are concentrated in the central and southern Shandong [6]. The influence of altitude on lightning needs to be studied due to the complicated topography in Shandong, so it is necessary to combine lightning parameters in Shandong and altitude data in Shandong for further analysis. In Shandong, 1,384 lightning disasters occurred in 2017, 9% in 2018 and 1,257 in 2019 [7]. Among all types of lightning strikes, home electrical and electronic equipment was the most damaged with 2,386 cases. Lightning caused 408 power supply failures, accounting for 11.52% of the total; 123 personal accidents, accounting for 3.56% of the total; Buildings were damaged in 129 cases, or about 3.1 percent of the total. According to incomplete statistics, about 3,518 resident televisions were destroyed, accounting for 73.9% of the total number of damaged home appliances, while computers, switches, telephones and other weak current devices were the main objects of damage to office equipment [8]. Only by studying the variation law and related factors of lightning current parameters with altitude and improving the early warning ability of lightning, can lightning disasters be effectively avoided.

In this paper, the global elevation data is used to obtain the elevation information of a certain place in Shandong province, and the elevation characteristics of lightning parameters at lightning flash point are obtained by superimposing 2D plane GIS map, the reasons for the influence of altitude on lightning parameters are analyzed, and the variation law of lightning parameters with altitude in this area is summarized.

2. Method

2.1. Spatial and Temporal Distribution Characteristics of Thunderstorms in Shandong Region

The number of annual thunderstorm days in an area is the number of days in a year when thunder can be clearly heard in the area [9]. The data of annual thunderstorm days obtained by meteorological observation stations in the whole region of Shandong province show that the spatial distribution of annual thunderstorm days in the whole region is mainly more in the middle and less in the east and west. Among them, the average number of thunderstorm days in the central region is more than 26 days, which belongs to the middle thunder area in concept, but the average number of days in the east and west sides is less than 26 days, which belongs to the low thunder area. The maximum value of the distribution of extreme value of annual thunderstorm days in the whole region was measured by the yiyuan meteorological observation station in zibo, and the number of days was 31. The minimum value occurred at the shidao meteorological observation station in weihai, with a number of days of about 17 days. In terms of the landform distribution of annual thunderstorm days, the central mountainous area of Shandong and yimeng mountain area of lunan and the Yellow River delta plain of lubei are located in the central region with more annual thunderstorm days. Among them, the main reason for the large number of lightning storm days in Shandong and zhonghe mountain areas is the effect of its topography and latitude. The intensity of the summer monsoon in Shandong region has a great influence. Therefore, the influence of the summer monsoon in the two mountain areas, the effect of terrain elevation, and the convection effect are significant, inducing the lightning storm days.

2.2. Temporal Distribution Characteristics of Thunderstorm Days in Shandong Region

According to the time distribution, thunderstorms occur in Shandong every year and every month. At present, the fastest lightning storm day was measured by linyi meteorological observatory on May 10, 1996, and the latest lightning storm day was observed by meteorological stations in yantai and weihai [10]. The results of the analysis of the average variation data of thunderstorm days in Shandong from 1997 to 2014 show that the average value of thunderstorm days in Shandong is 25 days, with the
maximum occurring in 1967 (about 41 days) and the minimum occurring in 2000 (only 16 days). During this period, the average number of annual thunderstorm days in Shandong showed a general trend of decreasing fluctuation. According to the chronology, the average number of thunderstorm days in the middle and late 1960s in Shandong was 35 days. The average number of thunderstorm days in the 1970s was 29. The average in the 1980s was 24 days. The average in the 1990s was 25 days; the first decade of the 21st century is 22 days.

2.3. Spatial and Temporal Distribution and Variation Characteristics of Ground Lightning in Shandong Region

The uneven spatial distribution of lightning is not only related to the large-scale weather system background, but also closely related to the lifting of terrain and the properties of underlying surface. The annual number of thunderstorm days can only provide basic climatic information for the study of lightning activity characteristics. To understand more specific characteristics of lightning activity, it is necessary to analyze the different characteristics of lightning activity caused by different conditions in the same region [11].

3. Experiment

3.1. Data Sources

(1) Lightning Monitoring Network

China's lightning location system was built in the late 1980s, for the introduction of the United States based on the directional and time difference comprehensive location method of lightning location equipment, with the first set of domestic lightning location system successful operation, China's lightning monitoring network began to network, until 2006 has formed the national power grid and the national lightning monitoring network. At present, on this basis, the regional power and meteorological departments have accumulated a large number of years of lightning monitoring data.

(2) Elevation Data Model

The elevation data model is mainly based on the data set of terrain data of the world (GTOP05/GTOP30), space shuttle radar topographic survey data, advanced spaceborne thermal radiation and reflected radiation digital elevation model Shared by the world, etc. ASTERGDEM is the most commercially available and accurate electronic terrain data set proposed by NASA and Japan in 2009, covering most of the land area with a vertical accuracy of 20 meters and a horizontal accuracy of 30 meters. In this paper, ASTERGDEM dataset is used to obtain elevation data in the research area.

3.2. Obtain the Altitude Attribute of Lightning Flash Point

The GlobalMapper software was used to load the GDEM data layer, divide the grid on the layer, determine the centroid coordinates of the grid, assign the elevation value to each centroid, associate the elevation attribute of centroid coordinates with the grid, and make the grid have the elevation attribute. Count the number of grids and the number of flash points in the range of corresponding altitude, and the related data table of lightning flow density and altitude can be obtained through calculation.

4. Discuss

4.1. Influence Analysis of Variation Law of Lightning Current Amplitude with Altitude in Shandong

In recent years, due to the application of lightning location system in power grid, the ability to obtain lightning current amplitude parameters has been greatly enhanced. In this paper, lightning location system is used to obtain lightning current amplitude parameters of lightning strike points in Shandong region and the relevant three-dimensional coordinates of lightning strike points are obtained by combining GlobalMapper software. The range of 1200–3200m above sea level is subdivided according to 100m of each section, and the average lightning current amplitude within the range of
each section is calculated. The relationship between the average lightning current amplitude and altitude in Shandong region is shown in figure 1.

![Figure 1. Relation Curve between Lightning Current Amplitude and Altitude in Shandong](image)

You can see from figure 1, the area negative polarity lightning amplitude increases with altitude increasing, normal polarity with the rise in altitude lightning amplitude decline slightly, and the region average normal polarity within the scope of each altitude lightning current amplitude than the average negative polarity lightning current amplitude difference is bigger, the reason is that normal polarity thundercloud position in the clouds.

4.2. Influence Analysis of Variation Law of Lightning Return Frequency with Altitude in Shandong

If the lightning strikes too many times in the process of a lightning, will occur in the lightning protection device before the lightning flow has no time to release into the ground, and again by lightning strikes. There have been many lightning arrester explosions and secondary lightning strikes on substation circuit breakers. The relationship between lightning strike times and altitude in Shandong is shown in table 1.

| Altitude /m | 1200 | 1600 | 2000 | 2400 | 2800 | 3200 |
|-------------|------|------|------|------|------|------|
| Lightning Return Times/times | 1.9  | 2.7  | 2.1  | 2.2  | 2.6  | 1.8  |

According to figure 2, when the altitude is 1200~2000m and 2400~3200m, the number of lightning return stroke fluctuates greatly. When the altitude is from 2000 to 2800m, the number of lightning return strokes increases with the increase of altitude.

4.3. Analysis on the Influence of the Variation Law of Ground Flash Density with Altitude in Shandong

Ground lightning density is a parameter that represents the discharge times of thunder cloud to the ground. The ground lightning density is measured by empirical formula. The ground lightning density can be directly calculated by dividing the number of lightning falling times measured by lightning positioning system by the area of lightning. Statistics in this paper, the object region is divided into multiple grids, within the scope of each elevation grid number, to get each altitude range corresponds to the surface area of value, and associated corresponding to flash point within the grid number, lightning current density and the altitude can be calculated, the relationship between ground flash density and the altitude in Shandong district relationship curve is shown in figure 2.
It can be concluded from figure 2 that when the altitude is 1300~1600m, the negative ground flash density decreases with the elevation of the altitude. When the altitude is 1600~2800m, the negative ground flash density increases with the elevation. When the altitude is 2800~3200m, the overall trend of negative ground flash density decreases. In the whole altitude range, the general trend of positive polar flash density is increased, which is obviously different from negative polar flash density.

5. Conclusion

The overall variation trend of negative lightning current amplitude in this area is increased with the increase of altitude, while the dispersion of positive lightning current amplitude is larger with the increase of altitude, but the overall trend is decreased. In the same altitude range, the average amplitude of positive polar lightning current is much larger than that of negative polar lightning current. The general trend of the change of the ground flash density of the negative lightning flow in this area is that it decreases first, then increases gradually, and finally decreases with the increase of the altitude. The general trend of the variation of the lightning flash density of the positive polarity increases with the elevation of the altitude. The general trend of the number of lightning return with altitude in this area is as follows: in the range of high altitude and low altitude, the number of lightning return fluctuates greatly; In the medium altitude range, the number of lightning return increases with the elevation. With the elevation of the area, the proportion of the normal lightning flashes in the total lightning flashes increases gradually.

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