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Characteristics of Temperature Variation along 330KV Transmission Lines of Yushu and Qinghai Main Networks in Recent 50 Years

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Abstract: Based on the 330kV transmission line project of Yushu and Qinghai main network, the characteristics of temperature changes along the line were analyzed in this paper. The transmission line crosses the permafrost section, and the engineering geological conditions of permafrost are complex and sensitive to environmental warming. Based on the temperature observation data of Gonghe station, Maduo station, Qingshuihe station, Xinghai station and Yushu station from 1960 to 2010, the regional temperature changes were analyzed. The results show that the temperature in the permafrost area along the transmission line has gradually increased in fluctuation for nearly 50 years, which will lead to changes in the permafrost environment. Furthermore, the temperature changes will have a certain impact on the stability of the 330kV transmission line permafrost area project of Yushu and Qinghai main network.

1. Introduction

The 330kV interconnection project between Yushu and Qinghai main network crosses the southeast edge of Qinghai Tibet Plateau and is located in the middle and low latitudes. The overall altitude is high, between 3200m and 5000m. The natural conditions along the line are bad and the geological conditions are complex. The line starts from Tangnaihai substation and ends at Yushu substation, and the overall line trend is north-south, with a total length of about 596km. Among them, seasonal permafrost accounts for 37.6% of the total length of the whole line, permafrost melting area accounts for 18.2%, less ice permafrost accounts for 23.8%, and ice rich, ice saturated and soil ice layer permafrost accounts for 20.4%. The permafrost with an average ground temperature greater than - 0.5 ℃ accounts for 60% of the permafrost of about 270km along the line, which belongs to high-temperature and extremely unstable permafrost [1]. It can be seen that the frozen land along the transmission line has high temperature, and the frozen soil section with high temperature and high ice content accounts for a large proportion and has strong hydrothermal activity, which is extremely sensitive to climate warming.

The main cause of frozen soil engineering diseases is the erosion of permafrost by water andheat [2]. Studies have shown that China's climate has warmed significantly in the past 50 years, and the greatest increase in winter temperatures. Especially in the past 30 years, the rate of warming is significant. The storage of frozen soil depends on the climatic conditions on which it depends. With the gradual global warming, the annual average ground temperature of permafrost increases relatively, causing permafrost degradation and thus affecting the physical and mechanical properties of permafrost. Among them, the research on the Qinghai Tibet Railway shows that the variation trends of precipitation, air temperature and ground temperature in the permafrost area have increased in fluctuation in the past 35 years from 1976 to 2010, and the climate in the permafrost area of the Qinghai Tibet Plateau is gradually warming [3].

2. Characteristics of Temperature Variation along the Transmission Line in Recent 50 Years

The 330kV interconnection project line between Yushu and Qinghai main network crosses the Qinghai Tibet Plateau. In this area, the altitude is high, the pressure is low, the intensity of solar radiation is relatively large, and the continental climate characteristics are obvious. Different underlying surfaces such as ice and snow, mud flow, gravel and grassland make the climate complex and changeable [4], and the change range of temperature is also very obvious.

2.1. Annual Average Temperature from 1960 to 2010

Table 1 shows the latitude and altitude of Gonghe station, Maduo station, Qingshuihe station, Xinghai station and Yushu station, as well as the average temperature in recent 50 years and the temperature rise range from 1960 to 2010. It can be seen that the annual average temperature for many years is the highest in Gonghe, followed by Yushu, Xinghai and Qingshuihe, and Maduo is the lowest. Among them, the annual average temperature of Maduo station and Qingshuihe station is negative, which are -4.5℃and -3.6℃ respectively; the average temperature of Gonghe station, Xinghai station and Yushu station in recent 50 years is positive, which is 4.1℃, 1.4℃ and 3.4℃ respectively. There is a certain relationship between temperature, latitude and altitude. Generally speaking, the temperature decreases with the increase of altitude and latitude. The difference between the average temperature in 2010 and the average temperature in 1960 can be roughly regarded as the warming range in recent 50 years. It can be seen that they are all positive, that is, the temperature increases. Among them, Gonghe station has the largest temperature rise of 2.8℃, while the five meteorological stations along the line have an average temperature rise of 1.6℃ in recent 50 years.

According to the data of Gonghe station, Maduo station, Qingshuihe station, Xinghai station and Yushu station, the change curve of annual average temperature in recent 50 years from 1960 to 2010 is drawn, as shown in Figure 1. It can be seen that the annual average temperature of the five stations is fluctuating and rising with the increase of time.

In 1997, the annual average temperature of Maduo station suddenly changed, and the temperature in the area decreased significantly compared with previous years, with a change of about 2.7℃. On the contrary, in 1997, the annual average temperature of Xinghai station reached the highest of 2.9℃ in recent 50 years, and the annual average temperature of Maduo station and Yushu station reached the highest of -2.5℃ and 5.3℃ respectively in 2009. The annual average temperature of Gonghe station and Qingshuihe station reached the highest of 5.9℃ and - 2.1℃ respectively in 2010.

The annual average temperature and ground temperature can be used as energy indicators to measure the climate state of a region [5]. The climate along the transmission line has been gradually warming in recent 50 years, which is consistent with the trend of global warming [6].

Table 1: The statistics of average temperature value

Place	Latitude/N	Altitude/m	Average temperature /℃	Heating range /℃	Rremarks
Gonghe railway station	36°35’	3200	4.1	2.8	Measured
Maduo railway station	34°54’	4200	-4.5	1.1	Measured
Qingshuihe railway station	33°48’	4500	-3.6	1.3	Measured
Xinghai railway station	35°35’	3300	1.4	1.5	Measured
Yushu railway station	32°55’	4200	3.4	1.6	Measured

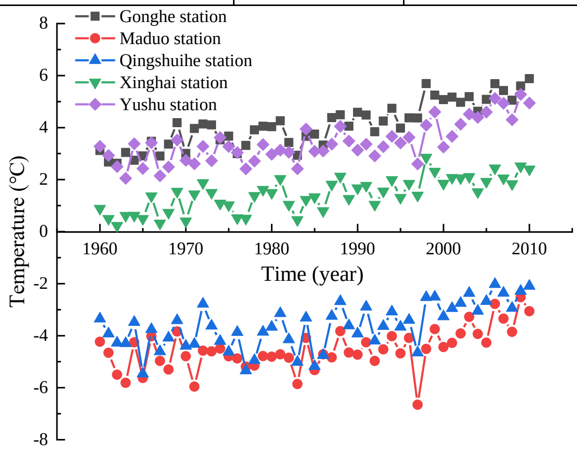

Figure 1: The curve of the annual average temperature change

2.2. Temperature Variation Trend along the Line in Recent 50 Years

According to the temperature change trend in recent 50 years along the line, the average temperature of five meteorological stations along the permafrost area of Yushu and Qinghai main network 330kV interconnection project line is counted in the same time period, as shown in Table 2.

Table 2: Every year the average temperature at 10a during 1960-2010

time slot/ year	1960-2010 Annual average temperature /℃				
	Gonghe railway station	Maduo railway station	Qingshuihe railway station	Xinghai railway station	Yushu railway station
1960-1970	3.1	-4.8	-4.1	0.7	2.8
1970-1980	3.8	-4.9	-4.1	1.2	3.0
1980-1990	3.9	-4.8	-3.9	1.4	3.3
1990-2000	4.6	-4.6	-3.4	1.8	3.5
2000-2010	5.3	-3.5	-2.5	2.1	4.6

To more intuitively reflect the heating trend along the line, polynomial fitting is carried out on the original data, and the fitted trend line is shown in Figure 2 ~ 6. It is the average temperature change curve of Gonghe meteorological station from 1960 to 2010. Figure 2 (b) is the original annual average temperature data of five meteorological stations in these 50 years, and figure 2 (a) is the curve obtained by polynomial regression fitting of the original data through data processing software. Compared with the linear fitting method, this method will retain the change trend of the original characteristics of the data.

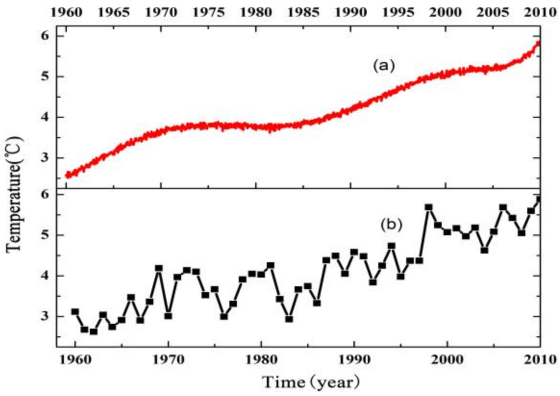

Figure 2: The temperature trend line at Gonghe Station during 1960-2010

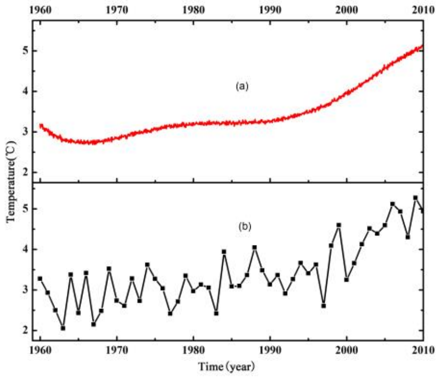

Figure 3: The temperature trend line at Yushu station during 1960-2010

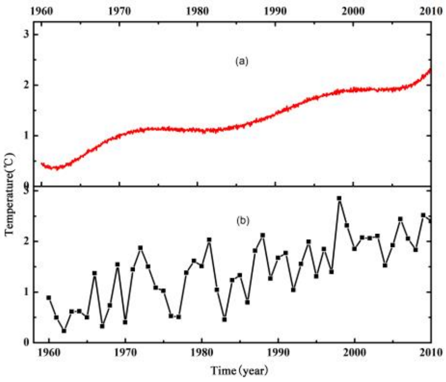

Figure 4: The annual temperature change trend line at Xinghai station during 1960-2010

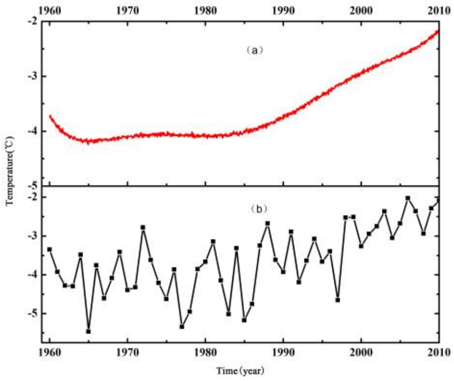

Figure 5: The temperature trend line at Qingshuihe station during 1960-2010

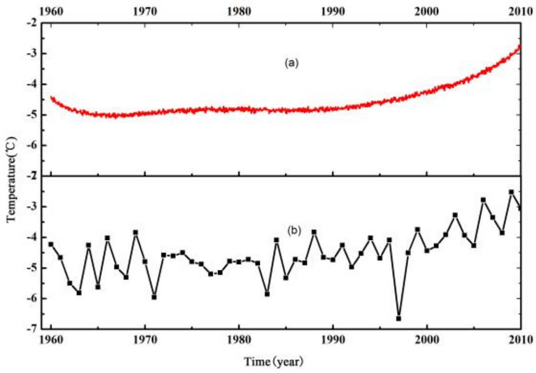

Figure 6: The annual temperature change trend line at Maduo station during 1960-2010

As can be seen from Table 3, the Gonghe station has the largest temperature rise in the past 50 years. Taking the Gonghe station as an example, from 1960 to 2010, the annual average temperature in the Gonghe station increased gradually, from 3.1 ℃ in 1960-1973 to 5.3 ℃ in 2000-2010, and the temperature rise rate reached 2.2 ℃ in the past 50 years. However, at the same time, it can be seen in Figure 2 (b) that there was a relative decline stage in the period from 1975 to 1980. The annual average temperature showed a relative downward trend with a small decline, but the annual average temperature was still higher than that before 1970. After 1980, the temperature began to rise gradually. Until 2000, the annual average temperature maintained a stable state near 5 ℃, and until 2005, the annual average temperature began to rise gradually. It can be seen from Table 2 that in these 50 years, the temperature rise in the area where Gonghe station is located has basically remained at about 0.7 ℃ every decade, which shows that the annual average temperature rise rate in this area is relatively large.

Table 3: The heating rate at every 10a during 1960-2010

time slot/ year	Heating rate every 10 years(℃/10a)				
	Gonghe railway station	Maduo railway station	Qingshuihe railway station	Xinghai railway station	Yushu railway station
1960-1970	/	/	/	/	/
1970-1980	0.7	-0.1	0.0	0.5	0.2
1980-1990	0.1	0.1	0.2	0.2	0.3
1990-2000	0.7	0.2	0.5	0.4	0.2
2000-2010	0.7	1.1	0.3	0.3	1.1

The overall change trend can reflect the fluctuating rise of temperature changes in the five meteorological stations along the permafrost area of the 330kV interconnection project line between Yushu and Qinghai main network in recent 50 years. Among them, the temperature rise rate of Gonghe station, Qingshuihe station and Xinghai station tends to be stable every ten years. Compared with Gonghe station, the temperature rise rate of Qingshuihe station and Xinghai station is relatively slow, and the rise rate of Gonghe station is 3.5 times that of Qingshuihe station and Xinghai station. The temperature rise rate of Maduo station and Yushu station also tends to be stable in the 40 years from 1960 to 2000. However, the temperature rise rate increased significantly in the decade from 2001 to 2010, indicating that the temperature in the area where Maduo station and Yushu station are located increased significantly in this decade. Figure 2 ~ 6 show the linear fitting curve of the annual average temperature change of five meteorological stations in recent 50 years, namely, Gonghe station, Maduo station, Qingshuihe station, Xinghai station and Yushu station. Although the curve cannot accurately reflect the annual temperature change relationship of the area, it can be clearly seen that temperature changes at these five stations are all characterized by an increasing trend in recent 50 years.

3. Influence of Temperature Change on Transmission Line Engineering

With the gradual increase of annual average temperature, it will directly affect the change of permafrost ground temperature. At the same time, the increase of foundation permafrost temperature will significantly reduce the strength of frozen soil foundation [7].

The above data show that the climate in the area where the 330kV interconnection project line of Yushu and Qinghai main network is located is gradually warming, which will inevitably lead to the change of the living state of permafrost. When the temperature in a certain area continues to rise, the temperature of the permafrost layer is bound to rise. For engineering structures, frozen soil is the sufficient condition for their existence, and the change of frozen soil conditions is bound to have a certain impact on engineering structures [8]. The temperature change within the unit vertical distance is called geothermal gradient, which can be divided into three types: endothermic type, zero gradient type and heat dissipation type. The change of geothermal gradient in the vertical direction in the permafrost layer may promote the permafrost layer to change from heat dissipation type to transition type or even heat absorption type. As a result, the design principles of new projects in this area and the measures to maintain the foundation strength and stability of existing buildings will also be changed. When the temperature rises significantly, it will seriously affect the change of ground temperature value, and the project will face many frozen soil engineering geological problems caused by the change of plane distribution pattern of permafrost For example [9], since the opening and operation of Qinghai Tibet railway, there have been a series of diseases in the subgrade crossing permafrost section, such as the development of longitudinal cracks on the sunny slope side, subgrade subsidence, ponding at the slope toe, longitudinal cracks on the cutting top on the right side of the cutting [10].

4. Conclusion

By analyzing the temperature data of five meteorological stations (Gonghe station, Maduo station, Qingshuihe station, Xinghai station and Yushu station) along the 330kV transmission line of Yushu and Qinghai main network in the permafrost area in recent 50 years, it can be seen that the temperature change trend in the permafrost area along the line has increased in fluctuation in recent 50 years. The climate in the permafrost area along the 330kV transmission line of Yushu and Qinghai main network is gradually warming. With the global warming, the increase of precipitation and the influence of frequent human activities, the environment of permafrost will inevitably change. Therefore, with the increase of ambient temperature, the permafrost may have permafrost degradation problems such as the rise of permafrost upper limit. Considering the characteristics of high average ground temperature of frozen soil along the transmission line, high temperature and high ice content, and large proportion of frozen soil, it is important to consider the impact of environmental warming and permafrost degradation on the engineering structures along the line during design and construction in order to ensure the safety and stability of the engineering structures along the line.

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