

# *Characterization of Electric Field Observation Interference and Analysis of Influencing Factors in Yanqing Zhangzhuang Tableland*

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**Keywords:** Goelectric Field; Yanqing Seismic Station; Variation Characteristics; Typical Event

**Abstract:** Based on the meticulous research of the goelectric field observation data collected at the Yanqing Seismic Station spanning from 2020 to 2023, this paper delves comprehensively into the main interference factors plaguing goelectric fields. Goelectric field observations are highly susceptible to multiple external elements. Industrial electrical activities, for instance, can introduce high-frequency electromagnetic interference due to the large-scale operation of electrical machinery. Meteorological factors also play a significant role; rainfall might cause changes in soil conductivity, leading to fluctuations in the observed data. Moreover, human activities near the station, like the construction of new infrastructure with heavy machinery usage, can generate artificial electrical noise. By analyzing the root causes behind each type of interference factor and closely examining the distinct characteristics of how the observation data varies, we are able to single out the typical interference factors. This detailed exploration ultimately offers a more nuanced and in-depth reference for accurately discerning the reasons behind abnormal changes witnessed in goelectrical observation data, facilitating more precise seismic monitoring and related research.

## 1. Introduction

The goelectric field is one of the important contents of geophysical field research, which mainly observes the surface component of the goelectric field and its change with time <sup>[1]</sup>, and on this basis, explores the ways and methods of the goelectric field observation used in earthquake prediction research practice. The interference factors of goelectric field observation mainly include observation system, natural environment, site environment, anthropogenic interference, and geophysics. Yanqing Zhangzhuang Seismic Station (hereinafter referred to as "Yanqing Station") has a good operation of goelectric field observation, high observation accuracy, and good data continuity, but with the development of the city, a variety of interfering factors are gradually increasing, and a variety of observational data patterns have been recorded in the daily observation. This paper analyzes and summarizes the various types of interference in the goelectric field observation of Yanqing Station, and provides a detailed reference for quickly identifying and eliminating the interference.

## 2. Station Overview

Yanqing Zhangzhuang Seismic Station is located in the northern edge of Yanhuai Basin, the geological structure belongs to the Yanshan Fold Belt, the Wolf Mountain-Huangbai Temple Fracture Zone is 3km northwest of the station, and there is a Guanting Reservoir 8km southwest of the station, the thickness of the Quaternary System of the area is 329m, and the underlying Jura Series sandstones. The observation site is an open and flat farmland without interference from large buildings, industrial facilities, high-voltage lines, and is far away from electrified railroads, substations and other sources of electromagnetic interference.

Yanqing Terrace geoelectric field observation began during the "Ninth Five-Year Plan" period, before September 1, 2020, the use of ZD9A-II, ZD9A-IIB geoelectric observation instruments, the output of the geoelectric field minute value. 2019, due to the construction of the Beijing Road, the geoelectric field reconstruction, September 5, 2020, updated to the GEF-2-type geoelectric field instrumentation observation, the surface concrete pole overhead to buried. From the surface of the concrete pole overhead to buried, laid along the NS, EW and N45°E direction, respectively, each measured direction laid long and short two measured direction, long measured direction of 300 meters, short measured direction of 200 meters; the use of unpolarized electrodes, buried depth of 5.5 meters (see Figure 1).

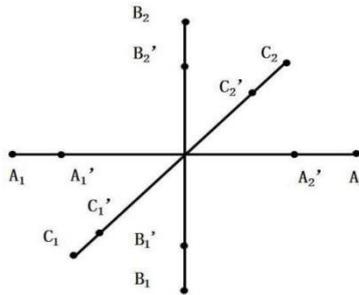


Figure 1: Pole diagram of the large earth electric field distribution at Yanqing station

## 3. Selection of information

According to the statistics of the results of tracking and analyzing the geoelectric field data of Yanqing station, the geoelectric field observations from September 2020 to April 2023 are presented. In this paper, the representative non-normal disturbance changes will be selected to be analyzed and discussed.

## 4. Analysis of normal observation data

During magnetic quiet days (generally with magnetic conditions  $\leq 2$ ), if there is no significant interference, the daily variation waveform of the earth's electric field observed by most stations in China mainly manifests as "double peaks and double valleys", sometimes also "single peaks and single valleys" and "double peaks and single valleys" [2], and a few stations do not have a daily variation waveform [3]. The Yanqing station has regular and clear diurnal waveforms, and the waveforms show a typical "double peaks and single valleys" pattern. As can be seen in Fig. 2, the minima in the north-south direction are around 11 o'clock, the minima in the east-west direction are around 12-13 o'clock, and the minima in the north-east direction are around 12 o'clock, but the trends in different directions are basically the same. The daily variation patterns and phases of long and short pole distance observations in the same direction are basically the same. Interference by the same site observation of ground resistivity, fixed burr jumps.

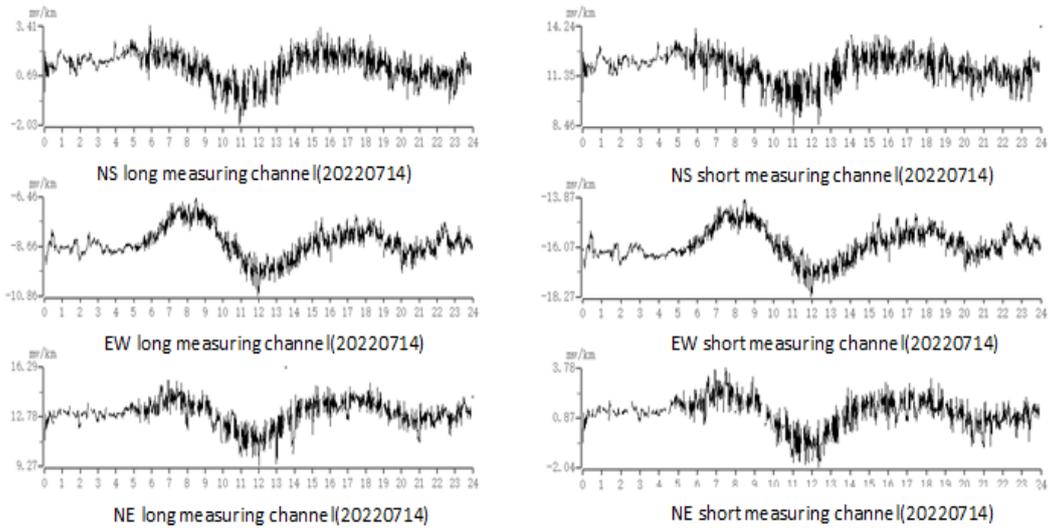


Figure 2: Observation curve of minute values of GEF-II geoelectric field meter at Zhangzhuang Terrace, Yanqing, China

## 5. Typical interference analysis

Through the combing of geoelectric field observation data, five main types of interference are summarized, namely, observation system failure, natural environment interference, site environment interference, man-made interference, and geophysical interference, and different types of interference are analyzed and summarized one by one in the following.

### 5.1 Observation system failure disturbances

The geoelectric field observation system is mainly composed of measurement lines, measurement electrodes, measurement instruments, lightning protection devices, and communication and processing systems [4], and the operation of each part will directly affect the quality of observation data. In the daily observation of the geoelectric field, if there are irregular changes in the observation data, the results of the same measurement direction long and short pole distance are not correlated, the simultaneous synchronization of multi-channel erroneous data, missing data or stopping the measurement, etc., it can be identified as the problem of the observation system, which can be determined by checking the line insulation to ground, checking the line connection parts, checking and calibrating the measuring instruments, and comparing the testing of the measuring electrodes and other processing methods, and can be checked and determined one by one.

External line failure: The original geoelectric field lines of Yanqing Station are made of copper cores in an overhead manner, which are prone to line aging after a long time, and may have poor contact caused by rust, or may be subject to temperature changes resulting in condensation of water droplets at the joints of the lines due to the lack of firm line wrapping. In the observation of geoelectric field, the observation data is very sensitive to whether the external line is intact, once there is a leakage of the external line or poor contact and other problems, the geoelectric field data will be accompanied by a large sudden jump, "step" changes or high frequency changes and other abnormalities [5]. 2019, due to the construction of the Beijing Road, Zhangzhuang Terrace on the geoelectric field renovation, instrumentation after updating to GEF-2 type geoelectric field instrument observation, it was changed from surface concrete pole overhead to buried, with

unpolarized electrodes and buried depth of 5.5 meters. After the renovation, the data changes caused by the line failure outside the new instrument were significantly reduced.

On January 2, 2022, the electric field meter at Zhangzhuang GEF-2 site showed a sudden change of data in the short east-west direction from 11:30-15:00, and no abnormality was found during the inspection of the site observation environment on the same day. 14:20-15:20 on January 18, the data again showed a large drop in the east-west direction, with a change of 48.2mV/km, and the inspection of the site was conducted at 16:00, and still no abnormality was found. 04:52-14:05 on January 21, data again showed a large drop in the east-west direction, with a change of 35.74, and then 14:06-18:02 data began to recover, with a change of 18.2mV/km. :52-14:05 East-west once again showed a large drop in data, with a change of 35.74, then the data began to recover from 14:06-18:02, with a change of 18.2mV/km. 07:00-10:47 January 24 saw a large and rapid increase in east-west long pole distance data, with a change of 9.1mV/km. January 24 13:39-14:06 Checked indoor switchboard connection wiring, checked and secured connections [6].

From January 2 to January 24, 2022, there were four changes in the east-west direction of the GEF-2 geoelectric field meter, while there were no changes in the other survey lanes. After a number of site inspections, no abnormality was found. On January 24, after checking each line in the east-west direction and re-fixing the line interface, the data in the east-west direction returned to normal, and since then no such changes have occurred, and it was finally judged that the reason for the changes was poor line contact (see Figure 3).

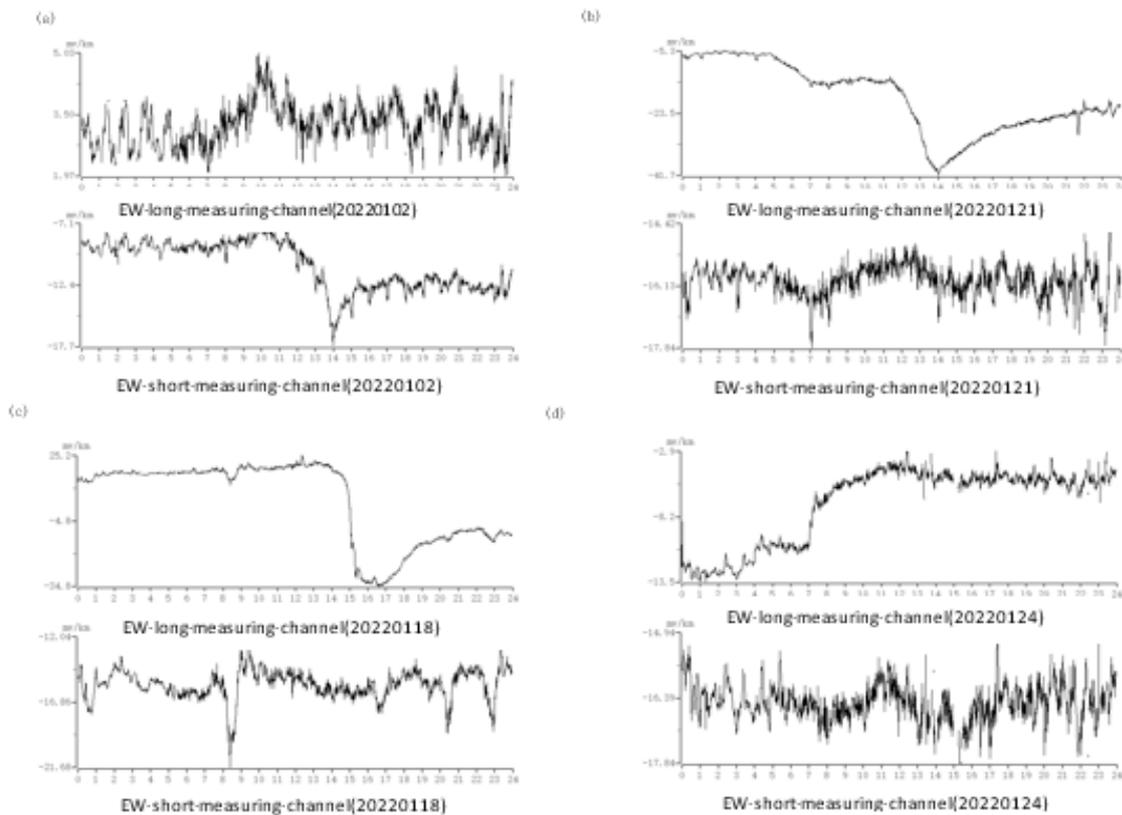


Figure 3: Observed curves of minute values of geodetic electric field of poor contact of outer line at Yanqing Zhangzhuang station from January 2 to 24, 2022

## 5.2 Natural environmental disturbances

Rainfall disturbance

Rainfall has a greater impact on geoelectric field observations, as rainwater infiltration into the soil causes changes in the resistivity of the subsurface medium, thus altering the normal day-to-day pattern of geoelectric field observations. Rainfall of different amounts and different degrees of urgency also have different effects on the geoelectric field observation. In general, when the rainfall is slower but lasts for a longer period of time, the rainfall reaches a certain level, causing the soil medium resistivity to change, thus changing the normal daily variation pattern of the geoelectric field observation data. When the rainfall is more rapid and the rainfall accumulates to a certain level for a short time, the rainwater directly seeps down to the electrodes, causing the electrode polarization, which generates an additional electrode polarization potential difference in the measurement loop, thus making the geoelectric field observation data appear aberrant [7].

On July 18, 2021, moderate rainfall of 25.4 mm and heavy rainfall of 33.90 mm occurred from 00:00 to 10:59, and the rainfall affected the north-south short-term data to jump downward with the magnitude of change of 29.3mV/km and 17.5mV/km, respectively, and both of them returned to normal within a few hours after the sudden jump. Short-term heavy rainfall on the observation data impact time is relatively short, the observation curve will appear aberration, the data downward jump, and then immediately begin to rise, generally within a few hours to return to normal. If heavy rainfall continues for a short period of time, the observed data may jump downward several times and then recover (see Figure 4).

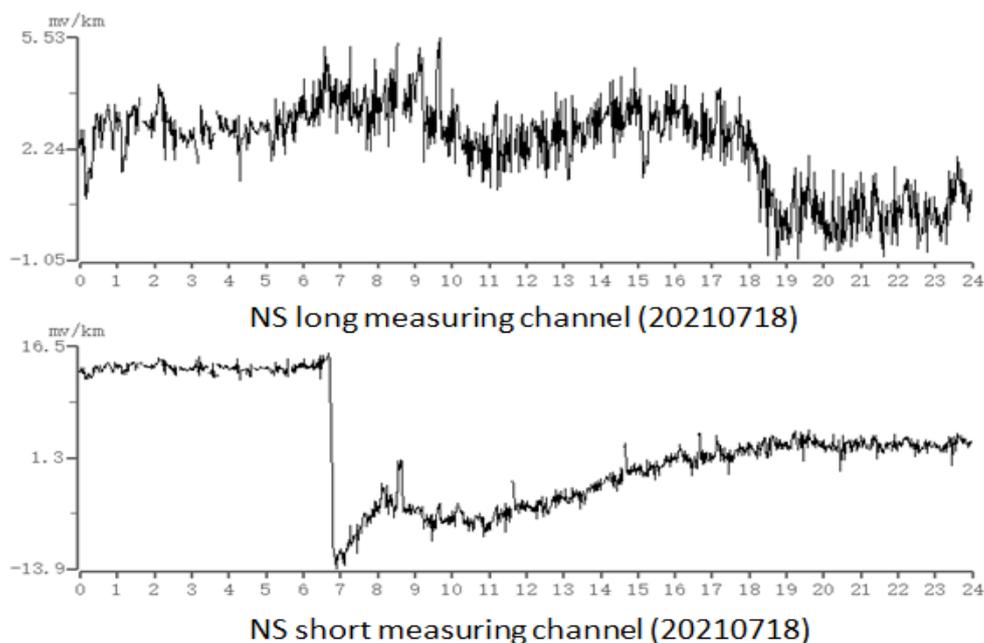


Figure 4: Observed curves of minute values of geodetic electric field affected by rainfall on July 18, 2021 at Zhangzhuang Terrace, Yanqing, China

### 5.3 Site environmental disturbances

Geo-electric field observation is very demanding on the environment, and changes in the environment in the measurement area often cause changes in the observation data. Geo-electric field observation instruments are very sensitive to changes in the earth's electric field in the measurement area, so once objects that change the magnetic environment appear in the measurement area, they will cause obvious interference in the observation data [8].

The main factor affecting the electric field data at Zhangzhuang Terrace is the urban railroad interference; engineering impacts and irrigation interference are temporary, while the urban railroad

interference is a long-term disturbance of the site environment.

(1) Engineering impacts

The observation of geoelectric fields requires high environmental requirements for the measurement area. Small changes in the measurement area environment often lead to changes in the observation data. If there are artificial power stray currents in the soil medium of the measurement area, the observation data will immediately experience strong disturbances.

From September 14 to September 15, 2022, Zhangzhuang station GEF-II was disturbed by the construction of the geoelectric field reconstruction in the measurement area, and the data of the six channels changed synchronously (see Fig. 5), and the six channels of the ground resistivity observed at the same site showed synchronous changes. As can be seen from Figure 5, when the construction led to the emergence of stray currents in the measurement area, the geoelectric field observation curve changed synchronously, the interference change pattern changed with a large amplitude, and the observation data reacted quickly to the construction power, which was rising or falling in a straight line.

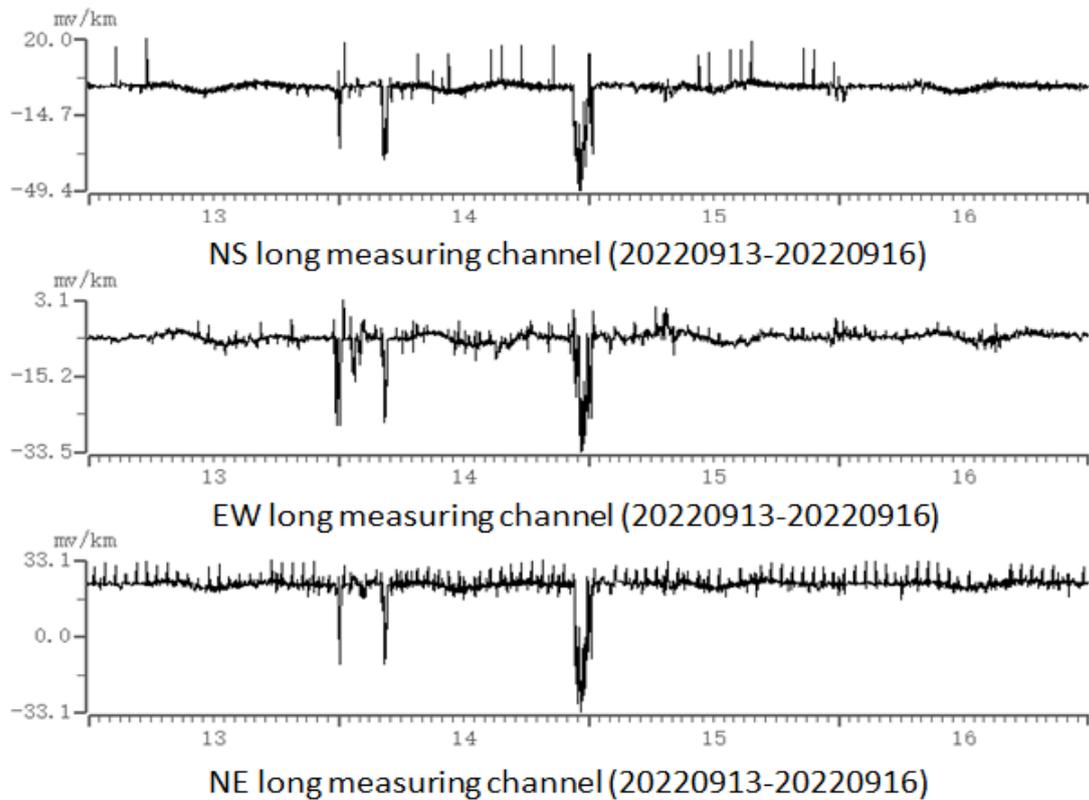


Figure 5: Observed curves of minute values of geodetic electric field affected by project leakage at Yanqing Zhangzhuang seismic station on September 14-15, 2022

(2) Urban rail transportation

Urban rail transportation interference is the only long-term environmental interference factor for the geoelectric field observation at Yanqing station, except for the absence of significant power-frequency environmental interference such as high-voltage lines and telecommunication transmission towers [9]. Urban rail transit uses high-power DC power equipment, and the leakage of the equipment changes the distribution of the electromagnetic environment, because the operation of urban rail inevitably makes the geoelectric field data disturbed.

On January 4, 2020, the GEF-II geoelectric field meter at Yanqing station was only disturbed by

the urban rail transit, and other than that, no abnormal disturbances appeared (see Figure 6). As can be seen from Fig. 6, during 00:00-05:00 when the urban rail transit stops running, the data change without burrs and the curve is relatively smooth, while during 05:00-23:00 when the urban rail transit is running, the data show obvious high-frequency burr-like disturbances, but the magnitude of the disturbances is small, and it does not change the basic shape of the daily variation of the geo-electric field observation.

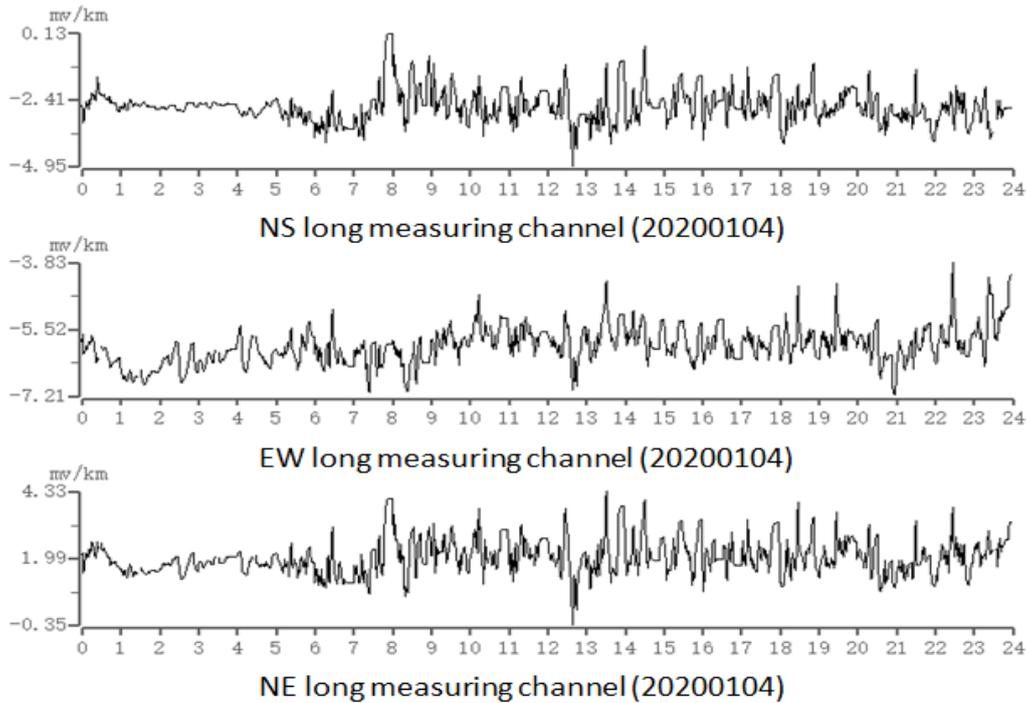


Figure 6: Observed curves of minute values of geodetic electric field at Yanqing Integrated Seismic Station on January 4, 2020, affected by urban rail transit

#### 5.4 Human interference

Since the geoelectric field observation system is a closed loop, in order to guarantee the reliability of the observation data, it is necessary to carry out regular line inspections to ensure its insulation degree. In practice, there are special circumstances also need to be temporarily disconnected from the geodetic field observation outside the line, which can lead to significant changes in the geodetic field data or produce erroneous data.

On September 26, 2022, Zhangzhuang Terrace tested/overhauled the GEF-II geoelectric meter. As a result of this, the GEF-II geoelectric field instrument observation data showed obvious changes (see Fig. 7). As can be seen in Figure 7, the interference of the instrument's testing/overhaul on the observed data is characterized by a straight line rise or fall in the observed data immediately after the external line is disconnected, and the change amplitude is several times of the normal value, and the change is obvious. When the external line was turned on, the data immediately returned to normal in the form of a straight line increase or decrease. As the change amplitude far exceeded the normal interference change, the curve suppression was obvious, and the normal observation data fluctuation curve before and after the interference was suppressed to a straight line or nearly straight line.

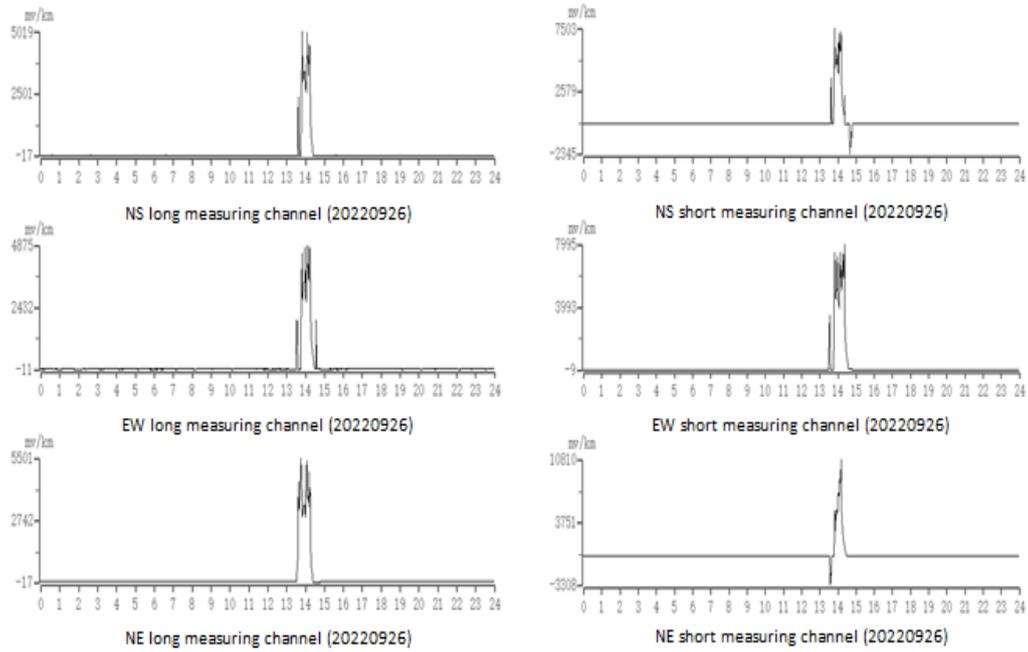


Figure 7: Observed curve of minute values of geodetic electric field affected by anthropogenic disturbance on September 26, 2022 at Yanqing Zhangzhuang Station

### 5.5 Geophysical events

A geoelectric storm is a strong change in the geoelectric field recorded during a magnetic storm, characterized by a large signal amplitude and wide distribution. A magnetic storm event is a global phenomenon of violent disturbances in the Earth's magnetic field caused by a high-speed plasma cloud arriving in Earth space. When a geomagnetic storm occurs, this global violent disturbance lasts for a period of ten to tens of hours throughout the magnetosphere, and all geomagnetic elements undergo violent changes, which cause changes in the earth's electric field, which are synchronized in a certain area with respect to the long and short polarity distances in the same direction of the earth's electric field <sup>[10]</sup>.

The magnetic storm phenomenon can be clearly recorded in the geoelectric field of Yanqing Station, and on February 27, 2023, the geoelectric field of Zhangzhuang Station was disturbed by a geoelectric storm, with a maximum K index of 7. As a result of this effect, the observation data recorded by the GEF-II geoelectric field instrument from May 5 at 11:00 to May 8 at 16:23 showed obvious changes, but the correlation coefficients were not significantly affected (see Fig. 8), and the correlation coefficient of the geoelectric field of Zhangzhuang Station was not significantly affected (Fig. 8), which is the same as that of the geoelectric field. As can be seen in Fig. 8, the disturbance of the geoelectric storm is characterized by the simultaneous occurrence of high-frequency pulses in the six channels of the geoelectric field, and the specific pattern of change is reflected in the rapid disturbance on the basis of the daily amplitude of change, which is basically the same in magnitude, with the same direction of maximum amplitude, and the correlation coefficients are unaffected. The change amplitude of the geostorm is positively correlated with the intensity of the magnetic disturbance <sup>[11]</sup>, and the duration is consistent with the time of the magnetic disturbance, and the geoelectric field observation data also return to normal after the magnetic disturbance ends.

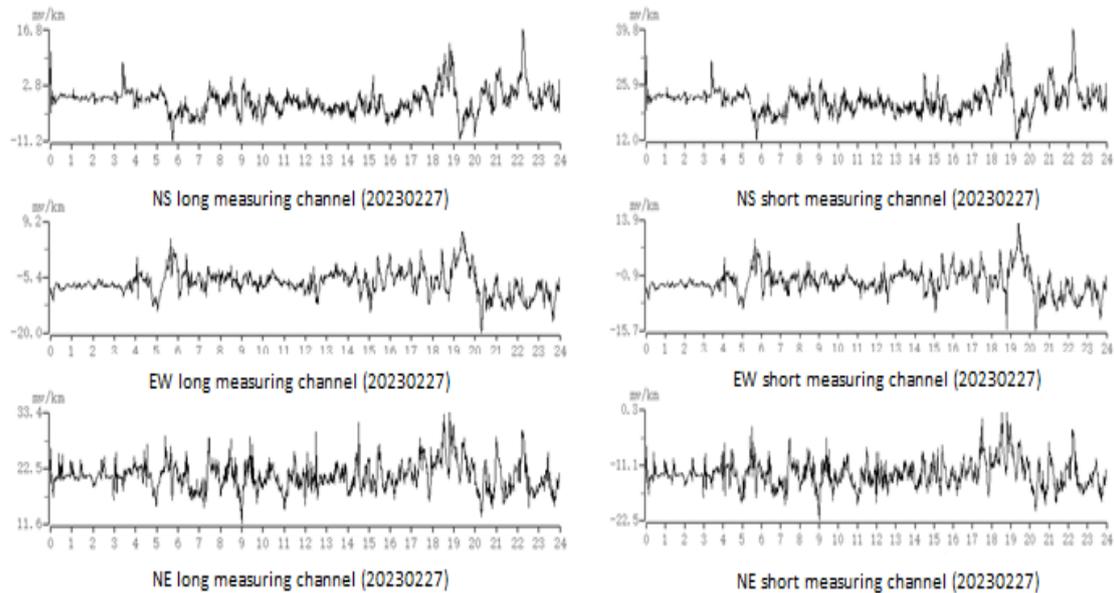


Figure 8: Observed curves of minute values of geodetic electric field affected by geoelectric storm on February 27, 2023 at Zhangzhuang Terrace

## 6. Conclusion

Yanqing Zhangzhuang terrace electric field observation interference factors are mainly observation system, natural environment, site environment, human interference and geophysical and so on. Among them, the failure of the observation system is mainly due to the failure of the outer line, which is manifested as the synchronized step change of the two channels with the same pole distance for many times, and the other channels do not have the same change; the interference of the natural environment includes rainfall, lightning and snowmelt, rainfall and snowmelt can change the normal day-to-day morphology of the earth's electric field, and lightning leads to the aberration of the observation data; the interference of the site environment mainly includes the impact of the project, irrigation, and urban rail transit, and so on. Engineering impacts lead to the synchronization of the observed data to appear a large change in the amplitude of the "rectangular square wave", irrigation usually leads to trend changes in the data curve, urban rail transit will cause high-frequency burr-like interference in the observation curve; man-made interference is mainly manifested as a straight-line rise or fall in the data curve, the amplitude of change is several times the normal value; geophysical factors Geophysical factors mainly refer to the interference of geoelectric storms, which is manifested in the synchronization of the observed data with obvious high-frequency pulses.

Through analysis and discussion, the factors affecting the electric field in Yanqing Zhangzhuang Terrace are mainly divided into three categories: the influence of the observation system, the influence of changes in soil conductivity, and the influence of external currents. Failure of the observation system and artificial power failure to repair the observation system are the influence of the observation system itself on the observation data. Due to system failure caused by data anomalies, you can analyze the data, determine the cause of the failure, instruments, electrodes, lines, etc. to carefully check, and timely solve the faults and problems existing in the observation system, to avoid the repetition of the same kind of interference, to ensure that the observation data

of the continuity and accuracy. Meanwhile, after testing the observation system or calibrating the instruments, it should be ensured that the system can resume normal observation in time without subsequent interference. Rain, snow and irrigation will lead to water accumulation, and water seepage into the soil will cause changes in the resistivity of the underground medium, which will lead to changes in the geoelectric field observation data. Therefore, it can be considered to avoid the influence of the natural environment on the observation data by remodeling the geoelectric field and adopting a new method of deep well electrode vertical geoelectric field observation. The main reason for site environment interference, such as engineering influence and urban rail transportation interference, is that the geoelectric field observation is interfered with by external stray current, and the observation data appear to have sudden jumps, "rectangular square waves" or burr-like changes. After this kind of interference occurs, the station personnel need to strengthen the patrol around the measurement area, find the data abnormalities and go to the measurement area in time to realize the cause of the interference, and carry out scientific processing of the interference data to ensure the correctness and reliability of the seismic monitoring data.

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