Study On the Mechanism of Atmospheric Electric Field Anomalies Before Earthquakes

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Abstract

Negative abnormal changes of atmospheric electric field have been monitored many times before earthquakes, especially before large earthquakes. However, its mechanism has not been clearly concluded yet. Based on the comparative analysis of the positive anomaly characteristics of atmospheric electric field before lightning and geoelectric field before earthquakes in earthquake areas, this paper concludes that the negative anomalies of atmospheric electric field before earthquakes are caused by the rise of the geoelectric potential in earthquake areas, and the areas with the abnormal rise of the geoelectric potential are potential earthquake areas. Based on the inference above , this paper further proposes a comprehensive earthquake early warning method with station network layout by geoelectric field instruments in combination with the atmospheric electric field data monitored by Electric Field Mills (EFMs). The research results will provide a possible reference for exploring the mechanism of earthquake generation, and will be help to explore earthquake early warning.

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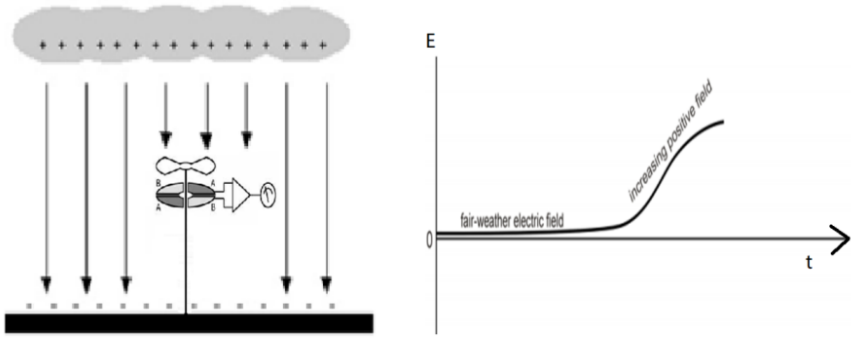

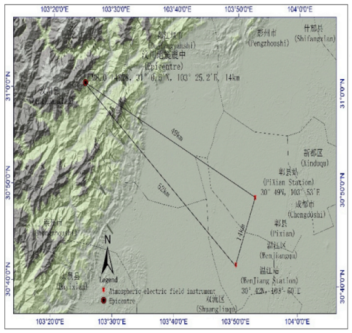

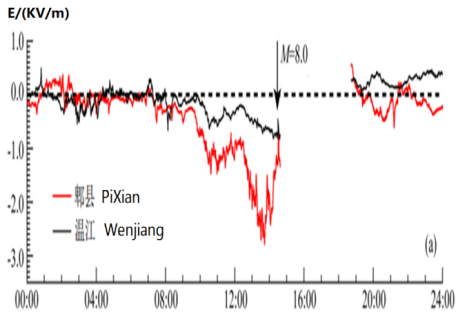

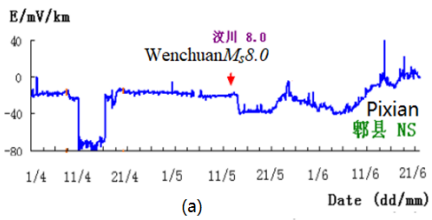

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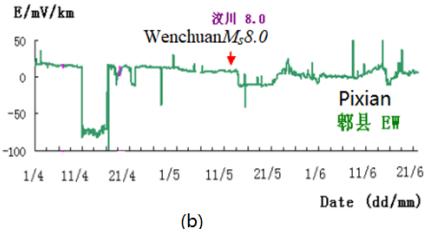

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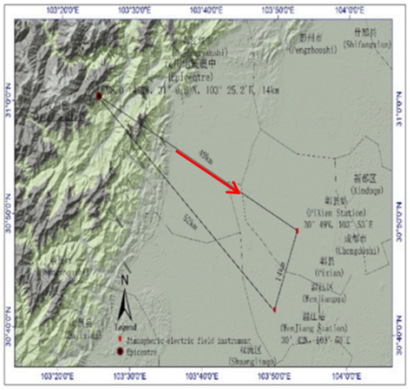

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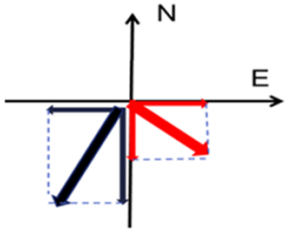
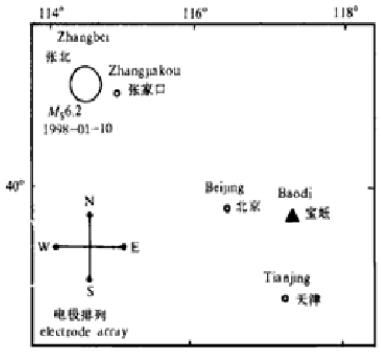
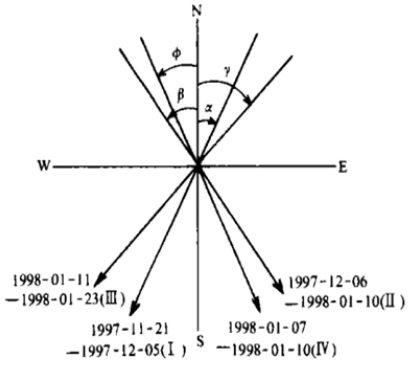


(d)





Study On the Mechanism of Atmospheric Electric Field Anomalies Before Earthquakes

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Abstract. Negative abnormal changes of atmospheric electric field have been monitored many times before earthquakes, especially before large earthquakes. However, its mechanism has not been clearly concluded yet. Based on the comparative analysis of the positive anomaly characteristics of atmospheric electric field before lightning and geoelectric field before earthquakes in earthquake areas, this paper concludes that the negative anomalies of atmospheric electric field before earthquakes are caused by the rise of the geoelectric potential in earthquake areas, and the areas with the abnormal rise of the geoelectric potential are potential earthquake areas. Based on the inference above , this paper further proposes a comprehensive earthquake early warning method with station network layout by geoelectric field instruments in combination with the atmospheric electric field data monitored by Electric Field Mills (EFMs). The research results will provide an possible reference for exploring the mechanism of earthquake generation, and will be help to explore earthquake early warning.

Key Words. Atmospheric Electric Field, Geoelectric Field, Earthquake

1. Positive anomalies of atmospheric electric field before lightning

Since the 17th century, scientists have been studying the phenomenon of atmospheric lightning. In 1920, British scientist Wilson [1,2] established a relatively complete concept of atmospheric circuit. It is found that when the sky is clear, there is always an electric field pointing to the ground in the atmosphere, and the electric

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potential gradient is about 100V/m. Although the scientific community has never had a clear conclusion on the formation mechanism of thunderstorm clouds, there is a clear consensus on the occurrence mechanism of lightning: if the electric potential difference between the bottom of the cloud layers and the ground reaches a certain degree, lightning will occur, and when the first discharge is completed, the electric potential difference between the bottom of the cloud layers and the ground becomes smaller, then the cloud layers gather charges again until the next lightning process.

In order to study the electrical characteristics of the atmosphere, scientists invented Electric Field Mill (EFM) to monitor the absolute electric field of the atmosphere relative to the ground, as shown in the left side of Figure 1. EFM is also used for early warning of lightning, and the basic principle of which is to measure the electric field of atmospheric cloud layers pointing to the ground. Taking the ground as zero potential, when the positively charged cloud layers approach, the atmospheric electric field will increase and a positive anomaly will occur. When the electric field increases to a certain extent, a lightning phenomenon will occur, as shown in the right side of Figure 1.

2. Negative anomalies of atmospheric electric field before earthquakes

At the same time, negative abnormal changes of atmospheric electric field have been monitored many times before earthquakes [5,6,7,8,9,10,11,12]. Some people try to find the cause, For example, Professor Harrison et.al mentioned the radon emanation [13]. Moreover, Freund et.al also given one the possibility from the stresses rock [14]. Especially before large earthquakes, the negative abnormal changes of atmospheric electric field are obvious, such as the 2008 Wenchuan earthquake in Sichuan province, as shown in Figure 2 [7]. The left side of Figure 2 shows the locations of EFMs in Wenjiang and Pixian counties, as well as the epicenter of the earthquake. The right side of Figure 2 shows the data of atmospheric electric field before the earthquake, from which it can be seen that the atmospheric electric field presented obvious negative anomaly within a few hours before the earthquake and

quickly recovered to normal after the earthquake.

The meteorological data shows that the weather condition before the Wenchuan earthquake was sunny, and there were no large number of clouds. Then according to the law of conservation of electric charge, the negative anomaly of atmospheric electric field could only be caused by a positive charge of the ground, i.e, the geoelectric field was at a high positive potential before the earthquake.

3. Positive anomalies of geoelectric field before earthquakes

In order to further confirm the result of the analysis above, we can analyze it directly from the perspective of geoelectric field. Reference [16] gives the data recorded by the geoelectric field meter at Pixian station, which is about 50km away from the epicenter of the Wenchuan earthquake. It can be seen from Figure 3 (a) (b) that an obvious discharge occured during the earthquake. Figure 3 (a) (b) does not specifically analyze the direction of the geoelectric field, but we can roughly deduce the direction change of the geoelectric field before and after the earthquake from the data.

The epicenter of the Wenchuan earthquake is located at 31.0° latitude and 103.4° longitude, and the location of the Pixian geoelectric field meter is about 30.6° latitude and 104.0° longitude. According to the data graph, before the earthquake, the NS electric field vector was about -20V/m, the EW electric field vector was about 40V/m, and after the earthquake, the NS electric field vector was about -40V/m, and the EW electric field vector was about -40V/m, as shown in Figure 3 (d). It is obvious that the electric potential at the epicenter before the earthquake was high, pointing from the Wenchuan epicenter to Pixian station (red arrow), and after the earthquake, it became pointing from the northeast to the southwest (black arrow).

Similarly, let's look at the 6.2 magnitude earthquake occurred in Zhangbei area, Hebei Province, China on January 10, 1998. The geoelectric field equipment located in Baodi, Tianjin recorded that the direction of the geoelectric field **E** vector (**E**=**E1**+**E2**, where **E1** is the SN component and **E2** is the EW component) changed

significantly. Before the earthquake, **E** vector was pointing from the Zhangbei epicenter to Baodi station, as shown in Figure 4 [6].

According to the changes in the direction of the geoelectric field before and after the earthquake, the whole process can be divided into four stages:

I:1997-11-21～1997-12-05 (before the earthquake);

II:1997-12-06～1998-01-10 (from the negative anomaly before the earthquake to the earthquake);

III:1998-01-11～1998-01-23 (from the earthquake to normal);

IV:1998-01-07～1998-01-10 (4 days before the earthquake).

The left side of Figure 4 shows the locations of the Zhangbei epicenter and Baodi geoelectric field equipment, and the right side of Figure 4 shows the direction of geoelectric field **E** in each period. It is obvious that the direction of the geoelectric field changed significantly before and after the earthquake. Before the earthquake, the geoelectric field pointed from the Zhangbei epicenter to Baodi station. This shows that an obvious positive anomaly of geoelectric field occured in the Zhangbei earthquake area before the earthquake, that is, the geoelectric field in the earthquake area was at high potential before the earthquake.

4. Analysis of negative anomalies of atmospheric electric field before earthquakes

The interior of the earth is equivalent to a complex and dynamic capacitor. With the analysis above, it can be determined that the geoelectric field in an earthquake area is at high potential before the earthquake, and a discharge phenomenon occurred during the earthquake, which has the same characteristics as lightning phenomenon in the atmosphere. From this, we can draw the following possible conclusions:

a) Earthquakes may be "underground lightning" phenomenons;

b) There may be an "underground lightning" earthquake type;

c) High geoelectric potential occurs before some earthquakes.

In case of a) b), it is the process of underground electric energy release -

earthquake is the process of underground lightning. Electric energy is converted into other forms of energy, including mechanical energy and light energy. The mechanical energy can produce ground vibration and generate ground sound, which explains the occurrence of earthquake phenomenons (ground thundering); The light energy can produce ground light, which explains the ground light phenomenons that can be observed during a large earthquake at night (ground flashing [17]).

In any of the cases above, the atmospheric lightning early warning principle can be used for earthquake early warning, and monitoring high potential of the geoelectric field can do help for earthquake early warning.

5. Suggestions and Prospects - Earthquake warning

Based on the mechanism research above, we can draw a conclusion that the principle of atmospheric lightning early warning can also be used for earthquake early warning, at least for some earthquakes. Special design can be made for EFM, such as avoiding the influence of meteorological factors. In the way of station network layout, multiple geoelectric field instruments can be used to monitor the direction of the geoelectric field in order to locate high geoelectric potential areas, i.e, the potential earthquake areas, and make a comprehensive judgment based on the monitoring data of EFMs.

The underground geological structure is far more complex than the atmosphere, so further in-depth research is needed. The research results above are just references for the scientific community.

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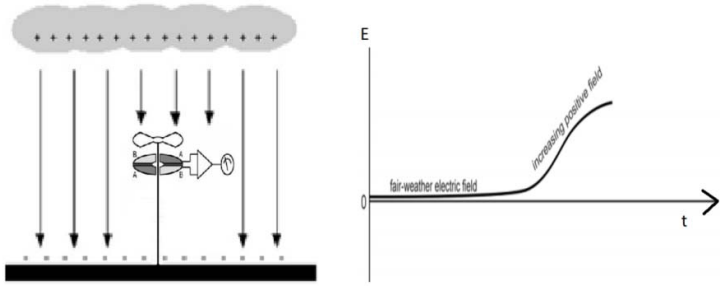

Fig 1 Schematic diagram of EFM and Increasing field due to approaching thunderclouds

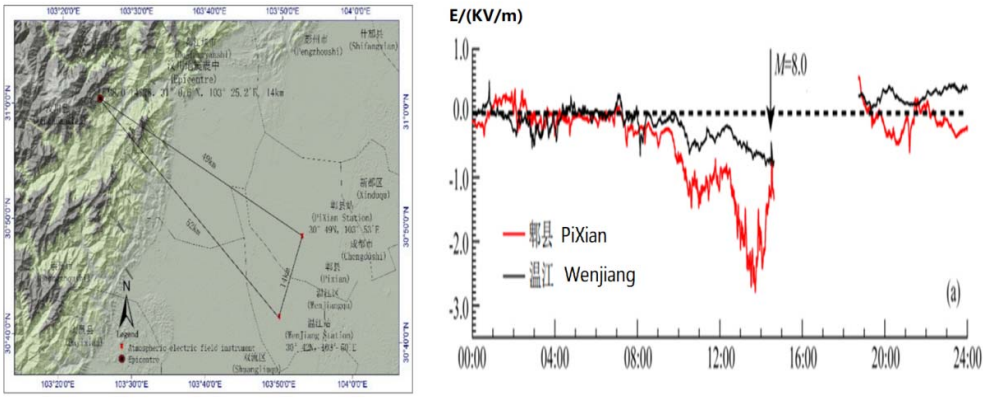

Fig. 2 The locations of EFMs in Wenjiang and Pixian counties, as well as the epicenter of the earthquake and The data of EFMs before the earthquake broke out

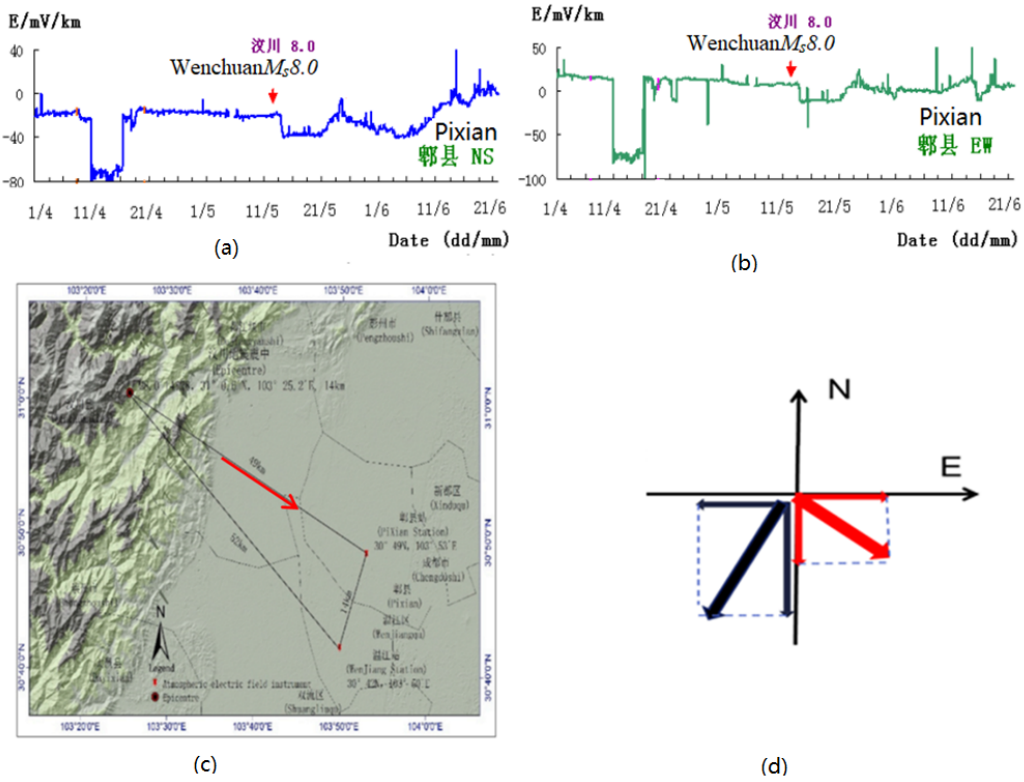

Fig. 3 The geoelectric field orientation diagram before and after the Wenchuan earthquake based on Pixian station data[18]

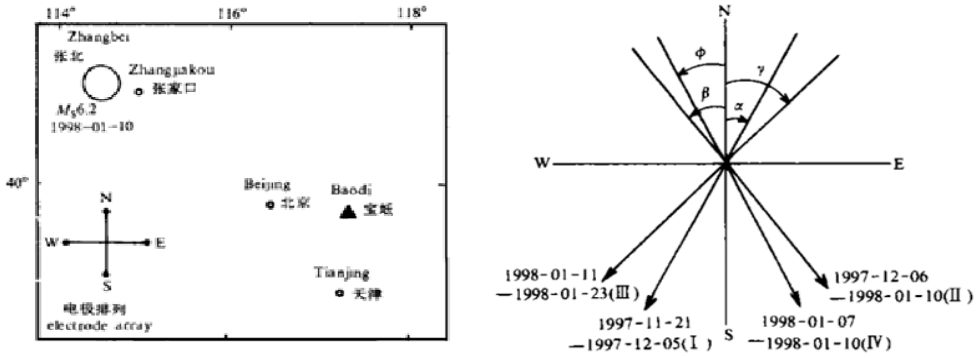

Fig.4 The relative position between the epicenter and Baodi station and The regnant direction

276 of the geoelectric field vector **E** in each stage in the process of the Zhangbei earthquake Ms 6.2
277 [17]

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288 Yuji Enomoto e-mail: enomoto@shinshu-u.ac.jp

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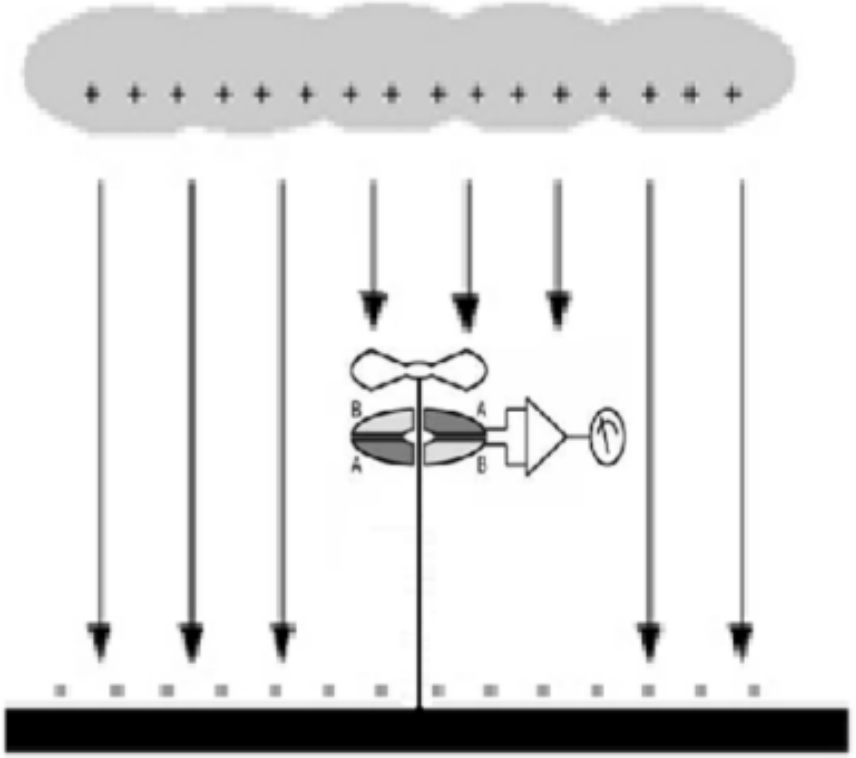
Fig. 1 Schematic diagram of EFM and Increasing field due to approaching thunderclouds.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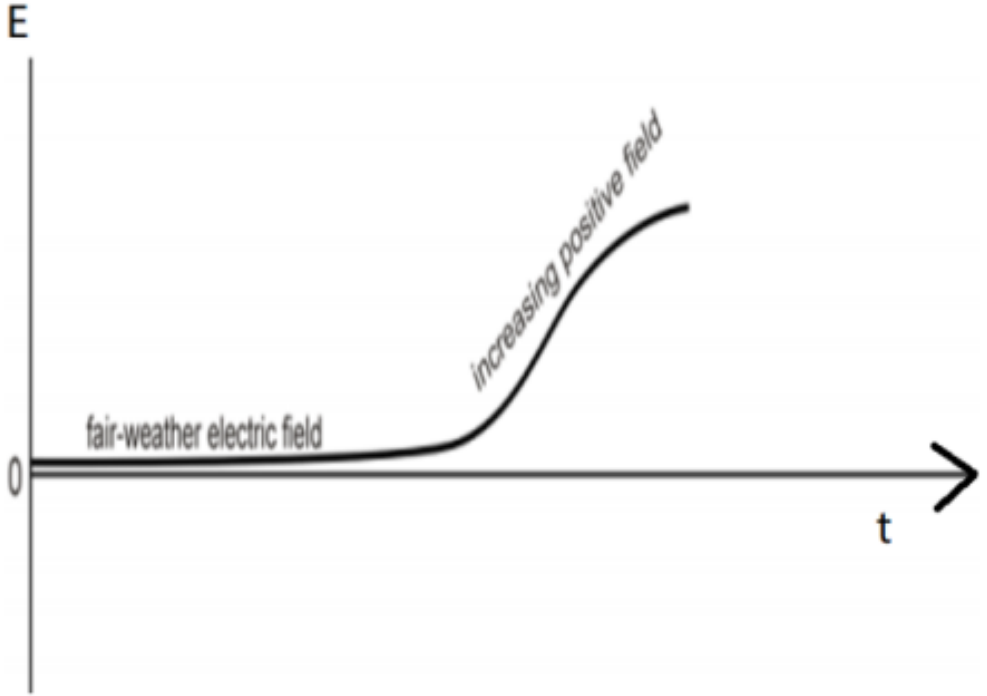
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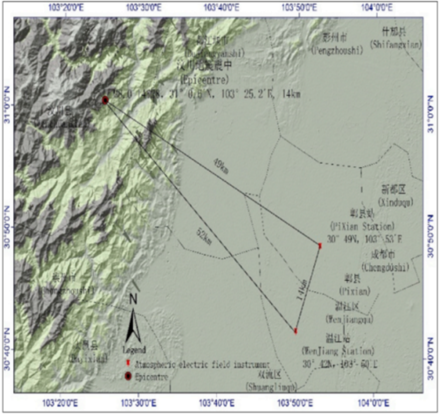
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彭州市
(Pengzhoushi)
什邡县
(Shifangxian)
49km
52km
14km
新都区
(Xinduqu)
(PiXian Station)
成都市
(Chengdushi)
郫县
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(WenJiang Station)
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Atmospheric electric field instrument
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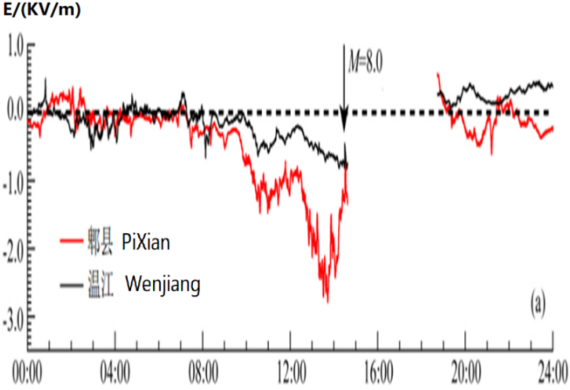
E/(KV/m)
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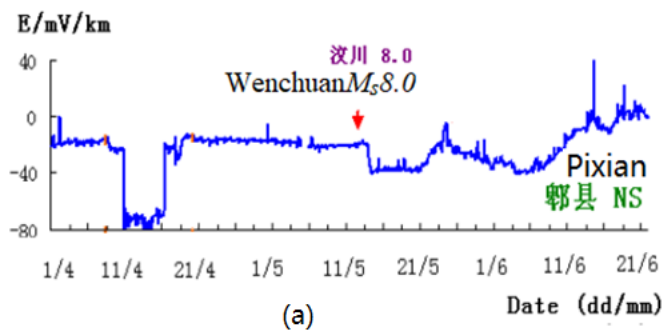
Fig. 3 The geoelectric field orientation diagram before and after the Wenchuan earthquake based on Pixian station data[18].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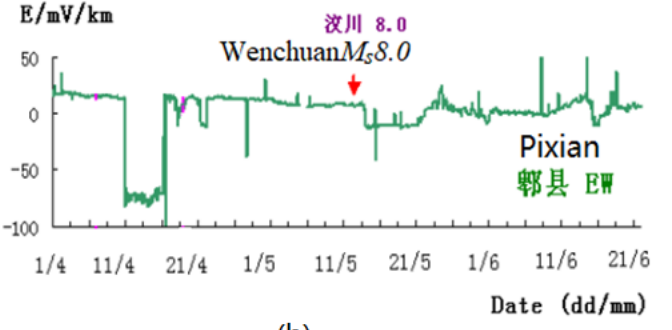
(a)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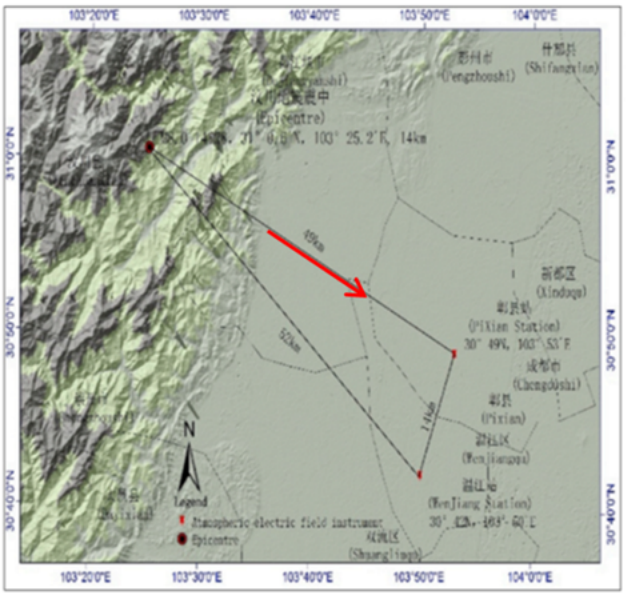
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Atmospheric electric field instrument
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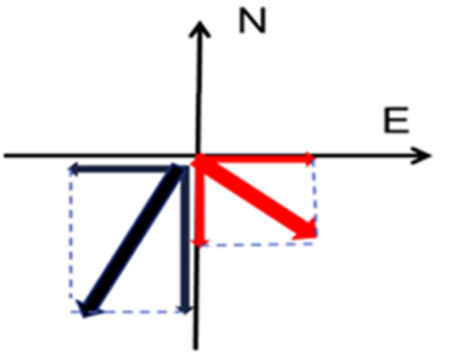
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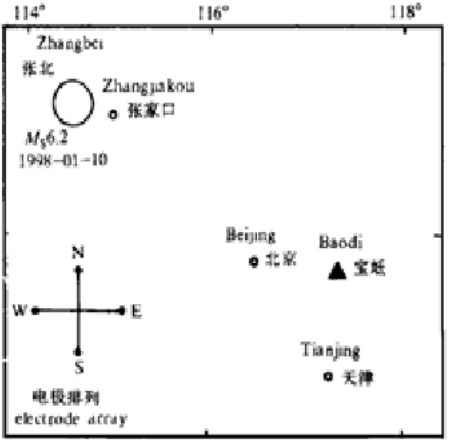
Fig.4 The relative position between the epicenter and Baodi station and The regnant direction of the geoelectric field vector E in each stage in the process of the Zhangbei earthquake Ms 6.2 [17].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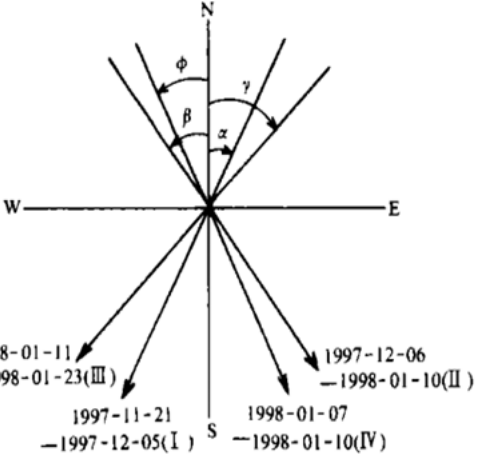
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