

# Use Remote Sensing Technique to Predict Earthquakes

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## *ABSTRACT*

This paper consists of two parts: one is the basic principle of the satellite thermal infrared increase temperature precursor .In trivially introduce “Red Swelling” theory on earthquake genesis and “Coupling Action” between the earth and atmosphere. Second part describes 2 events of successful earthquake prediction examples and characteristics of satellite thermal infrared increase temperature precursor.

**Keywords:** “Red Swelling” theory, Satellite thermal infrared images, and Earthquake prediction

## 1. INTRODUCTION

Due to the development of the space technology, now the mankind can take the whole earth as an object of study. Therefore, a broad prospect has been opened up for resolving a series of global problems, such as monitoring and research of air pollution, green-house effect, ozonosphere destruction, soil desertification, storm, flood .It also gives us the possibility to use the satellite thermal infrared wave band to monitor the temperature changes of various interfaces on the earth, to seek for the thermal radiation phenomenon related to the indication of earthquake, to monitor seismic activities, to make short term and impending earthquake prediction and to reduce the disasters which the earthquake would bring to the mankind (Qiang Zuji et al.,1991a).

Comparing with the existing up to now earthquake prediction technology and methods applied in studies of seismic monitoring and prediction the remote sensing technology is of Unique superiority, because it monitors the dynamic evolution of the thermal anomaly on earth surface macroscopically and can put up the accuracy of earthquake prediction in three elements (time, location and magnitude). But the shortcoming of this method is that the thermal infrared radiometer carried by meteorological satellite today can not pass through the cloud layers, the temperature value on the ground under the clouds can not be measured directly.

People have already recognized the temperature-increase anomaly before earthquake and studies have been made on this phenomenon. With the method of stationary network observation, temporal temperature data can be obtained in limited sites instead of the entire seismogenic the entire area to reveal the complete dynamic evolution. However, it is of advantages to use the thermal infrared (IR) radiation of meteorological satellite to detect the ground temperature, such as data accuracy, large area coverage, a large amount of information and the capability of capturing the time-space dynamic variation of the temperature -increase before earthquakes (Qiang Zuji et al., 1991a). However relevant work on the relation of the thermal IR anomaly of meteorological satellite with the seismic activity are only found in the former Soviet Union (Golnei and Salman, 1988). We used thermal IR anomaly of meteorological satellite to monitor and tried to predict the earthquake of Oct.18, 1989 in Datong, Shanxi Province and other shocks, and obtained preliminary idea and method for carrying out impending prediction in this way.

From 1990 to July in 1997, total of 80 predictions have been made, of which 12 were relatively accurate (actual

magnitude of the earthquake within Ms 0.5 of the predicted magnitude and the epicenter within 10km of the predicted area), 20 predicted the magnitude to within Ms1.0 and the epicenter to within 200~300km, it means basically accurate. 8 were not so good (actual epicenter several hundred km from predicted area), 40 were false alarms, and 19 failed to be predicted (CEOS, 1995).

## 2. FUNDAMENTAL PRINCIPLES

Using satellite thermal infrared temperature increase anomaly as the earthquake precursor and putting it into practical use appeared only three or four years ago. About 20 years ago, Academician FU Chengyi, 1971, a famous seismologist of China, presented his “Red Swelling” theory on earthquake genesis. On the basis of many years’ observation, he noticed that:

- (1) The records of Granting Reservoir Seismological Station, Beijing, are usually interfered by the high-frequency pulses produced by trains passing a nearby bridge. But during the periods of Baotou earthquake of November 1970 and Changshan islands earthquake of January 1971, such interference disappeared. Hence the appearance of this type of high-frequency pulses is indeed correlated with the occurrence of earthquakes, which proves that before a larger earthquake, the affected area of the upper crust may stretch at least several hundred kilometers.
- (2) Before a larger earthquake, the occurrences of small earthquakes in a relatively wide area decreased dramatically, and a transient quiescent period appears.
- (3) Some earthquake precursors such as ground water anomaly, ground tilt, crust strain, geoelectric resistivity, and anomalous animal behaviors sometimes may appear in places far from the epicenter. If an earthquake was caused only by fracture of rocks, such phenomena would occur magnificently only around the area near the epicenter.
- (4) Gravity of the moon and sun triggers earthquakes sometimes. While the gravitational force is a kind of body force, it affects on rocks at both sides of a fault nearly equally. If earthquakes originated only from a small area near a fault, it is hard to imagine that the gravitational force could trigger an earthquake. Only when this force affects a very large volume of the crust, could the gravitational force produce enough distortion. Professor Fu Chengyi regarded these facts as a support for his Red Swelling theory of earthquake genesis.

Recently Professor FU has developed his theory. In 1993, he pointed out (FU Chengyi, 1993), “Such transference (between the source and its medium) of energy and matter before or during an earthquake may produce various kinds of boundary phenomena of coupling between the solid earth and the atmosphere, i.e., physical, chemical, biological and other sorts of phenomena. Actually, if we do not limit the formation of earthquake source to the displacement of rocks within a local region, but in a much wider underground region, the crust layer in a much larger active area might be the information source concerning the earthquake. This is the reason why there are precursors before an earthquake” . He explained further: “Some of such phenomena may be produced by the coupling with surrounding material or the atmosphere, with the initial source under the ground surface, such are the meteorological precursors. That is why we regard satellite thermal infrared temperature increase anomalies as true earthquake precursors” .

Senior engineer Zhu Qingzhong from State Seismological Bureau, while observing the water level at Tayuan well, Beijing, discovered that the water level of Tayuan well demonstrated obvious anomaly before the M5.3 South Yellow Sea earthquake of Jan.24, 1992, occurring 1000km away from Beijing and the M5.4 Sunitu Youqi earthquake, Inner Mongolia of September 30, 1991 occurring 750km away from Beijing. According to our four years’ observation of

satellite thermal infrared temperature increase anomaly, we found that the temperature increase anomaly of an earthquake of magnitude 7.0 may spread as much as 1000km, and the maximum temperature increase anomaly area of an earthquake of magnitude 6.0 could be several hundred kilometers in diameter. All these facts proved that the occurrences of earthquakes are resulted from rock movement in a much larger area, just as Academician FU Chengyi had pointed out.

In 1991, several earthquakes (Tangshan earthquake, Luanxian earthquake, Hejian earthquake and Bohai Sea earthquake) occurred in sequence near the capital region. (Table 1) (Qiang Zuji et al., 1993a). During these earthquakes we observed variation of the CH<sub>4</sub>, CO<sub>2</sub> contents of low altitude atmosphere, the low altitude atmosphere electric field and the satellite thermal infrared temperature increase anomaly simultaneously, and these phenomena were correlated with each other in space and time, suggesting that the pre-earthquake thermal infrared anomaly is caused by the increase of CH<sub>4</sub>, CO<sub>2</sub> content of the low altitude atmosphere and the variations of atmospheric electric field.

### 3. SOME SUCCESSFUL EXAMPLES

#### 3.1. Changshu Earthquake

The Changshu earthquake Ms5.1 occurred at 17:57 (GMT, here in after) on February 9, 1990, and it was sensible around Shanghai, Wuxi and some other places. The epicenter was at 31.6°N, 121°E. We predicted on February 6, 1990 that there would be an earthquake with magnitude 5-6 in the south Huanghai Sea-north Jiangsu Province region. The fact is that the time and magnitude are relatively correct. The location is several tens of kilometers away. This prediction is basically right (Qiang Zuji et al., 1992).

An outstanding characteristic of the earthquake precursor is bursting increase in temperature of thermal infrared channel obtained from meteorological satellite telemetry. Photo 1 presents mainly the temperature field distribution of the Huanghai Sea surface, in which an isolated brown area can be seen very clearly around 35°N, 121~122°E. This is the anomalous area of temperature increase with an area of about 50,000km<sup>2</sup> (in fact it is more than 50,000 km<sup>2</sup>, because some part of it was covered by clouds). The temperature in this area was 3~5°C higher than that in the surrounding areas. The light blue and blue color on the east side of this area shows the cumulus line formed by cold air entering the sea, in the meantime the temperature was increasing in the central part of Shandong Peninsula and around Lake Taihu. In Photo 1 all the light blue and blue regions represent clouds. After February 1, the temperature increase area of the Huanghai Sea was extended and varied. For example, at 18:28 on February 5 the area evidently extended more than three times and mainly expanded toward the west and south. Photo 2 at 5:54 of Feb.6 there was a cloud line trending nearly EW on the north side of temperature increase area. At that time the Shandong Peninsula and Jiangsu Province was clear and the temperature was increased clearly. Based on the image map of February 6, 1990, we predicted the earthquake. The anomalous area in North Jiangsu has extended toward south and reached Changshu epicenter. Photo 3 at 20:32 of February 8 the Huanghai Sea was slightly clouded. The temperature increase area moved to the sea surface out of the Changjiang delta area and east side of Hangzhou Bay. At this time the temperature increase area was 150,000 km<sup>2</sup>.

#### 3.2. Tangshan Earthquake

Based on the thermal anomalous temperature increase, we predicted that there would be an earthquake of magnitude 5 in the Tangshan and Luanxian areas. The predicted valid period would be from Mar. 30 to April 16, 1998. As expected, there did occur an earthquake of magnitude 4.7 on April 14 1998 at E118.3°<sup>o</sup>, N39.7°<sup>o</sup>, in the Tangshan area. The fact is

that the three elements (Time, Location and Magnitude) are accurate, It is successfully predicted.

In early Mar 21,1998,there appeared anomalous temperature increase in the thermal infrared band of meteorological satellite in the north part of Huabei plain .The temperature increase region sometimes moved northward to Tangshan-Luanxian areas. During Mar. 22-24 the temperature increase is continuing.

#### 4. CONCLUSION

The satellite thermal infrared temperature increase as precursors of earthquake has the follow characteristics:

- (1) The abnormal temperature increase area is identifiable. Usually, it demonstrates itself as an isolated body in the thermal infrared images, and could be distinguished from such noises as those temperature anomaly caused by whether processes.
- (2) Our prediction practices prove that using thermal infrared temperature anomalous increase as earthquake precursor is universally valid.
- (3) The temperature of the anomalous area is 2~6°C higher than that of its surroundings.
- (4) The larger the area of temperature abnormal increase is, the larger the magnitude of future earthquake is.
- (5) Location of the future earthquake can be predicted based on the dynamic evolution of satellite thermal infrared anomalies.
- (6) Based on our observations and experiments(Qiang Zuji et al.,1995),we could suggest a preliminary model on the mechanism of temperature anomalous increase as following:

Rocks under stresses can produce terrestrial degassing and emission of CH<sub>4</sub>, CO<sub>2</sub> and charged particles, with the existence of solar radiation and electric field excitation thermal infrared temperature may increase.

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