RESEARCH ON THE CHANGES OF THE TIDAL FORCE AND THE AIR TEMPERATURE IN THE ATMOSPHERE OF LUSHAN (CHINA) MS7.0 EARTHQUAKE

by

Weiyu MA [a], Xiangzeng KONG [b, c,*], Chunli KANG [a], Xiaohong ZHONG [a], Haiyan WU [b], Xiaoshan ZHAN [b], and Monika JOSHI [c]

[a] China Earthquake Administration, Beijing, China
[b] Fujian Normal University, Fuzhou, China
[c] University of Ulster, Belfast, UK

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The cycle process of the tidal force of celestial body for Lushan M7.0 earthquake, occurred in Lushan county of Sichuan, China on April 20, 2013, was calculated. The earthquake occurred at the lowest point phase. It indicated that the type of seismogenic fault that the tide force acted on belonged to the thrust fault. According to the tidal cycle, the abnormal air temperature change was analyzed based on National Center for Environmental Prediction satellite data around the whole China before and after the earthquake. The result showed that the air temperature changed evidently with the tide force changing. In temporal, the change went through: initial air temperature rise → strength → reaching abnormal peak → gradually decline; in spatial, the abnormal area winded its way along the margin of the southern Qinghai-Tibet Plateau and went through: scattered → conversion → scattered procession. The procession was similar to the change procession of a rock breaking under the stress loading. This shows that the stress change of rock may cause the air temperature change in the atmosphere before and after earthquake. It indicated that the tidal force of celestial body could trigger the earthquake, when the tectonic stress reaches its critical broken point and the air temperature anomaly was proportional to the seismic tectonic stress change. It was useful to combine air temperature and tidal force in earthquake precursory.

Key words: *air temperature, tidal force, Lushan earthquake, changes*

Introduction

With the rise of abnormal radiation monitoring tectonic activity before the quake with the satellite remote sensing observation [1] and application research [2], remote sensing technology provides a reliable way for acquiring information accurately, quasi real time, and rapidly, which is more concerned by seismologists. Recently, there are many kinds of thermal infrared anomalous recognition methods such as based on image interpretation which were statistically significant [3] difference analyze [4] compute-assisted statistical techniques (Robust Satellite Technique – RST) [5] a comparison of brightness temperature en-

* Corresponding author; e-mail: xzkong@fjnu.edu.cn

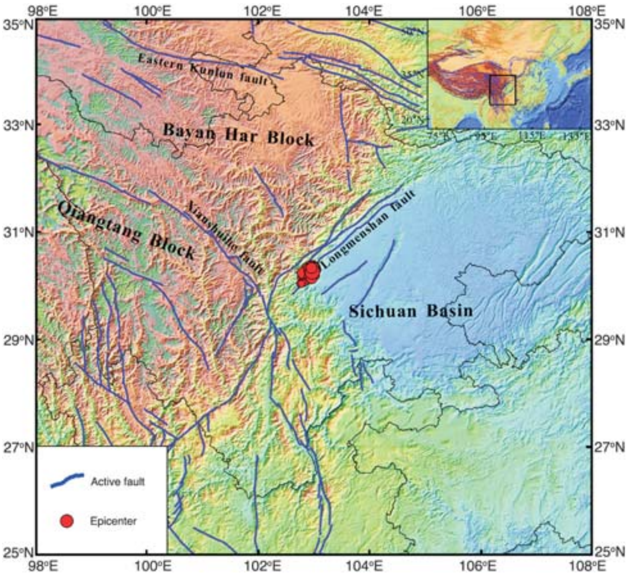

Figure 1. The epicentre of Lushan, China, earthquake and main active faults in investigative area

hancement anomalous points with others [6] based on vortices calculation of digital image enhancement [7] and based on time-frequency transformation method to conduct wavelet transform and power spectrum [8, 9], *etc*., which accumulate abundant materials for the remote sensing earthquake prediction. But there are problems need to be solved: a contradiction whether the earthquake is suitable between rare events and certain event-based statistic algorithm. A difference of anomalous judgment led by random of data time windows length selection in the statistical process and uncertainties in the process of selecting different Fourier split-window of standard functions in the wavelet transforms and power spectrum [10]. Earthquakes are results of mechanical processes inside the Earth. Therefore, it is necessary to introduce the mechanics into remote sensing technology. However, at present, the immeasurable crustal stress makes the problem into deadlock. It indicates that the tidal force is the external mechanical factor to trigger the earthquake when the tectonic stress reaches its critical broken point [11, 12]. It is also the only calculable physical parameters of earth deformation, which are advantage in time. Therefore, this paper study Lushan earthquake which integrates tidal force with air temperature.

Tectonic setting

According to the China Earthquake Networks Center, at 08:02 on April 20, 2013, a Ms7.0 earthquake occurred in Lushan County, Sichuan Province. The epicenter was located at 30.284°N and 102.955°E and the focal depth was about 20 km (see fig. 1). Earthquake located in the intersection of southern longmenshan fault, eastern bayankala block and eastern xianshuihe fault, southern margin of block, a meeting region of the active Qinghai-Tibel and stable Sichuan Basin. The focal mechanism solutions show that the seismogenic fault (the fault of Lushan earthquake occured) belongs to thrust fault, and the regional tectonic activity was strongest in the global earthquake activity [13, 14].

Tidal force

Tidal force is cyclical continuous variation. It triggers the phase with the earthquake and change with the structure. We summed up that the earthquake occurred at the lowest point phase when the type of seismogenic fault belonged to the thrust fault [15, 16]. Using the calculation method of tidal force [17] as follows:

According to the calculating method of Calvin, the tidal-generating potential $W_i(P)$ that any object on any point P in the Earth's interior:

$$W_i(P) = k\frac{M}{r_i}\sum_{n=2}^{\infty}\left(\frac{r}{r_i}\right)^n P_n(\cos Z_i) \tag{1}$$

where $P_n(\cos Z_i)$ is the $(\cos Z_i)$ Legendre polynomial of order n, Z_i – the zenith distance of the star, M – Moon or Sun's mass, k – gravitational constant, r – the distance of the epicenter from the Earth's center, and r_i – the distance of the star's center from the Earth's center. To the moon, r_m is the Moon-Earth distance. To the Sun, r_s is the Sun-Earth distance.

For Moon under present conditions we assume $n = 2, 3$, respectively, have:

$$W_{Moon-2}(P) = \frac{3}{4}k\frac{M_m}{r_m}\left(\frac{r}{r_m}\right)^2\left\{\begin{matrix}(1-3\sin^2\varphi)\left(\frac{1}{3}-\sin^2\delta_m\right)+ \\ +\sin 2\varphi\sin 2\delta_m\cos H_m+\cos^2\varphi\cos^2\delta_m\cos 2H_m\end{matrix}\right\} \tag{2}$$

$$W_{Moon-3}(P) = \frac{3}{4}k\frac{M_m}{r_m}\left(\frac{r}{r_m}\right)^3\left\{\begin{matrix}\frac{1}{3}(3-5\sin^2\varphi)\sin\delta_m(3-5\sin^2\delta_m)+ \\ +\frac{1}{2}\cos\varphi(1-5\sin^2\varphi)\cos\delta_m(1-5\sin^2\delta_m)\cos H_m+ \\ +5\sin\varphi\cos^2\varphi\cos 2H_m\end{matrix}\right\} \tag{3}$$

Likewise, for Sun we assume $n = 2$:

$$W_{Sun-2}(P) = \frac{3}{4}k\frac{M_s}{r_s}\left(\frac{r}{r_s}\right)^2\left\{\begin{matrix}(1-3\sin^2\varphi)\left(\frac{1}{3}-\sin^2\delta_s\right)+ \\ +\sin 2\varphi\sin 2\delta_s\cos H_s+\cos^2\varphi\cos^2\delta_s\cos 2H_s\end{matrix}\right\} \tag{4}$$

For the whole of Earth has:

$$W_{Moon+Sun}(P) = W_{Moon-2}(P) + W_{Moon-3}(P) + W_{Sun-2}(P) \tag{5}$$

where δ_s, δ_m are day and month declination, respectively, and φ is the latitude of epicenter.

Using this calculation formula of tidal force, the continuous curve of tidal force changing with time for the epicenter of Lushan earthquake from March 22, 2013 to May 21 was calculated. Where the horizontal axis represents the time sequence and the vertical axis represents the pressure that was produced by celestial tidal forces [units-Gal]. As shown in fig. 2, the variations of tidal force of celestial orb before and after Lushan Ms7.0 earthquake are showed.

Staring from April 20, 2013, tidal force of celestial body went through three (marked A, B, and C) continuous and obvious periodical change: stay trough → reaching peak → return to trough. Earthquake struck at April 20

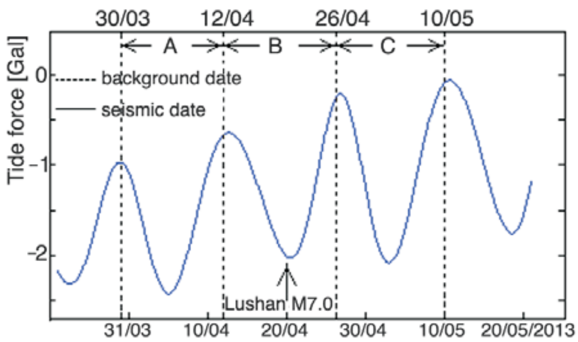

Figure 2. Variations of tidal force of celestial orb before and after Lushan Ms7.0 earthquake

(arrow), tidal force located in low phase, which indicated that the seismic tectonic zone triggered by tidal force belongs to thrust fault, which is also the same with the conclusion of focal mechanism (fig. 2). It showed that tidal force has certain inducing effect on this earthquake.

Spatio-temporal variation of air temperature

After years of exploration, there are huge possible variations in selecting remote sensing data type and the range of earthquake remote sensing monitoring area. In this paper we select data based on the following consideration: firstly, when solving the problem of researching tectonic activity by remote sensing parameter; we chose air temperature as a research target because air temperature reflects the comprehensive properties of underlying surface, parameter of energy variation.

Secondly, in order to ensure continuity and universality of data to be used in this study, it has been taken from NCEP. The data has been maintained by the National Center for Environmental Prediction (NCEP) and National Center for Atmosphere Research (NCAR) for over 50 years [18]. Their spatial coverage is (1 × 1 arc degree) of latitude by longitude covering global grid of (360 × 181), and the time range is from 1954 till now. At last, to test efficiency of abnormal monitoring, we focus on China territory (spatial coverage is 22°N - 46°N; 80°E - 120°E).

In the course of the concrete analysis, we choose the air temperature data of April 12, 2012 (a turning point of nearest high point which is also a turning point of tidal force in the period of tidal force) as reference background. Figure 3 clearly illustrates the abnormal air temperature change that only appeared on the region around the whole China before and after the earthquake.

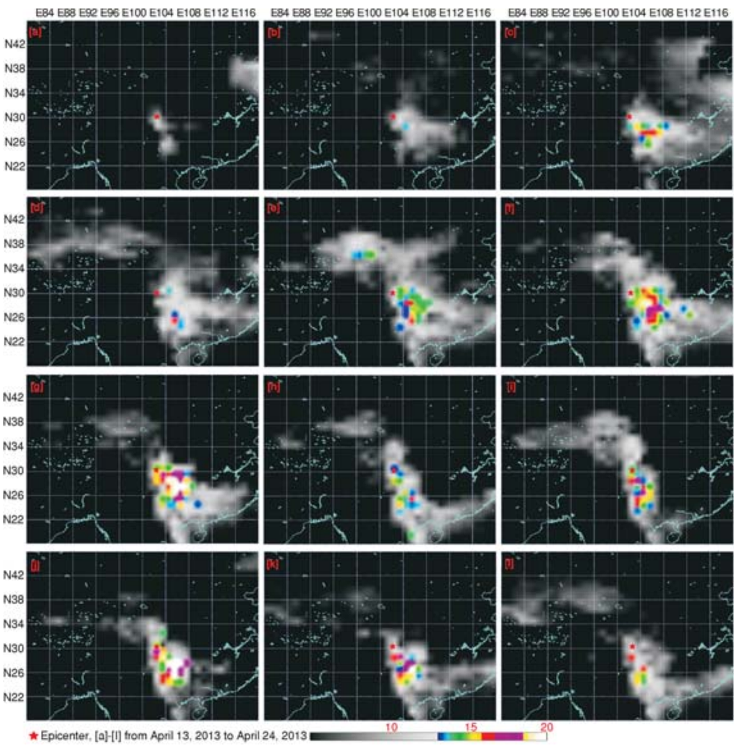

Figure 3. Spatial-time evolution of air temperature anomaly increase of Lushan Ms7.0 earthquake

Then, the background was subtracted from the air temperature (06:00 UTC) at 900 (hPa), with day by day, same time and same scope from April 13, 2013 to May 23, 2013 and a continuous and daily variation image before and after this earthquake was obtained, as the basis of anomalous analysis of the impending earthquake (see fig. 3). On 13th April the air temperature stayed in a calm state. On 14th April, the anomalies appeared at southeast of the epicenter. On 15th April, the anomalies migrated to the epicenter. On 16th April, the anomalies were expanded in southeast. From 17th to 18th April, the anomalies were continually expanding. At the same time there are maximum of temperature in Chengdu city according to Chengdu meteorological station data. On 19th April, the anomalies continued. On 20th April, main earthquake happened. After the earthquake, the anomalies suffered from attenuation.

Discussion

It is observed that in this earthquake, anomalous evolution of the air temperature data in temporal went through: initial air temperature rise → strength → reaching abnormal peak → gradually decline; in spatial, the abnormal area winded its way along the margin of the southern Qinghai-Tibet Plateau fault and went through: scattered → conversion → scattered procession. And better spatial corresponding relation exists between position of abnormal radiation and epicenter of the quake.

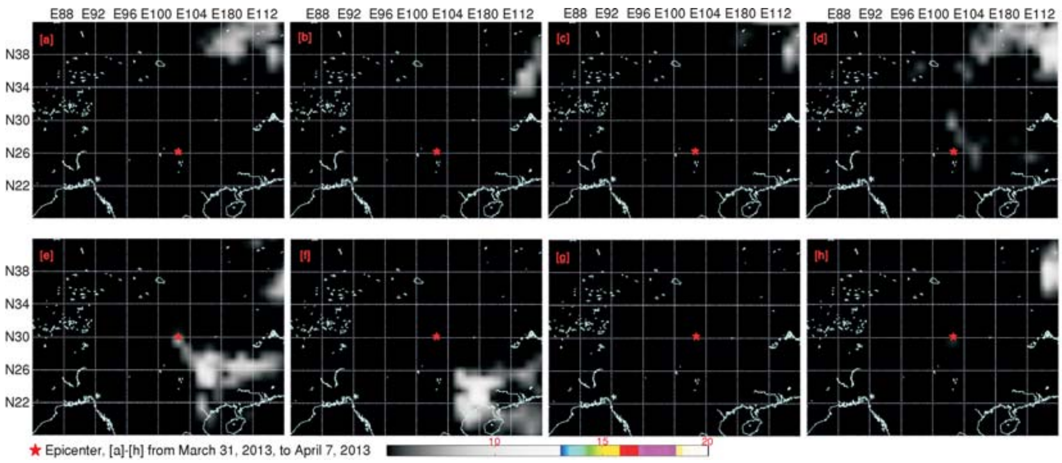

Figure 4. Spatial-time evolution of air temperature in the cycle “A”

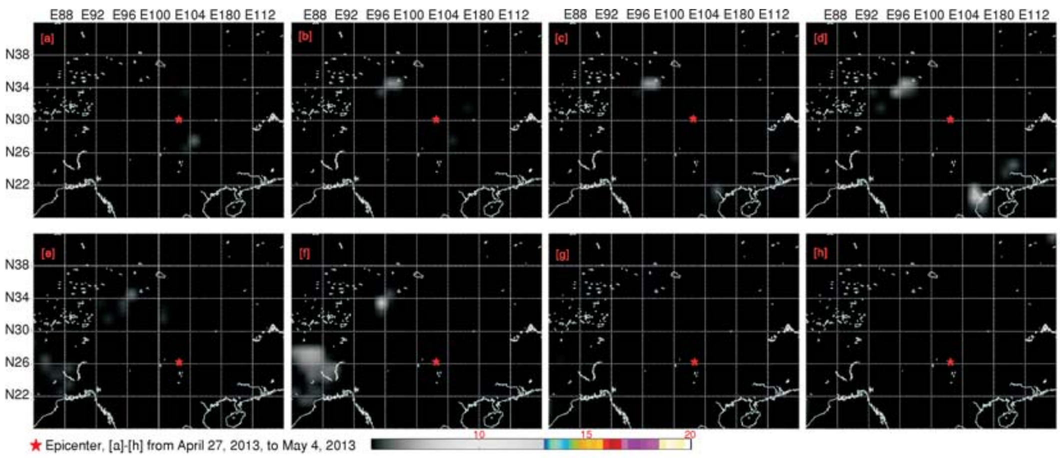

Figure 5. Spatial-time evolution of air temperature in the cycle “C”

The procession was similar to the change procession of rock breaking under the stress loading: compression → rock micro-fracture → rock fracture propagation → stresses locking → rock fracture terminates [19]. Basic response to temporal evolution processing: tectonic stress loading of rock → quasi-static nucleate → dynamic cracking → stress redistribution → fault intensity resume again [20]. Instead, at the same phase of the tidal cycle A (from June 17 to June 25, 2013) and C (from July 1 to July 8, 2013), obvious the air temperature anomalies were not found in this area (see figs. 4 and 5), therefore no earthquake occurred.

Conclusions

Tidal force has obvious periodicity, but it would not be at the same phase for each cycle. Hence, it is a critical issue to judge the time period when the stress will reach its critical condition [21]. Through analysis above, we preliminarily believed that when tectonic stresses of rock at the hypocenter reaches the critical condition of rock breaking and sliding, the tidal force of celestial body would trigger the earthquake, and the air temperature anomaly may be the physical manifestation of radiation in the process.

Owing to the air temperature anomaly images of periodic tidal force, the spatial/temporal evolution showed an obvious correlation with rock stress loading and breaking process, that led to the earthquake near Lushan. A short and disconnected thermal anomaly that appeared in Outer Mongolia, as lacking of an evolutionary character involved in rock mechanics breaking processes, earthquake did not occur. This showing that tidal force may provide a certain anomalous initial time for remote sensing earthquake monitoring, so that avoid the randomness of background. In addition, it is possible to proclaim that the feature of tectonic setting's evolution process of stress → strain → breaking complied with continuous factors of stress → microcrack → breaking → locking based on the unification of the air temperature anomaly prior to earthquake with the mechanics basis via the tidal force to obtain image via remote earthquake monitoring instead of scattered, polycyclic or leap.

However, it has not been clear how the change of tidal force modulates and triggers the earthquake to occur and how they affect anomalous radiation, especially earthquakes influenced by non-seismic factors such as terrain, topography, and general circulation of atmosphere underlying surfaces. In future, therefore, the research on the physical mechanism such as tidal force which triggers quake and precursory and regular aspects of anomalous radiation exploration are necessary to enhance early – warming capacity in certain areas prior to strong earthquake.

Finally, the air temperature decay process prior to the quake on 19th April perhaps is a sign of lock-up period of rock stress, which may provide a direction to the upcoming earthquake.

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