Overview of Earthquake Early Warning Information Release System in Fujian Province, China

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Abstract. Earthquake early warning is a technical method that can effectively reduce earthquake disasters. In May 2018, the Fujian Earthquake Agency officially provided information services such as earthquake early warning and earthquake quick report to the public through dedicated receiving terminal and the smart phone application named “Fujian Earthquake Early Warning”. This article briefly introduces the preliminary work of the Fujian Earthquake Early Warning Data Processing System, and focuses on the construction of the Fujian Earthquake Early Warning Information Release System. Finally, taking the M6.4 earthquake in Yilan in 2019 as an example, the actual effect of the earthquake early warning information service is introduced.

1. Introduction
Since the founding of the People's Republic of China, the number of earthquake deaths in China accounted for 52% of all natural disaster deaths. Facing such grim situation, how to effectively reduce the casualties and economic losses caused by the earthquake and realize the shift from focusing on post-disaster relief to pre-disaster prevention, becomes the problem that emergency management agency needs to solve. It is difficult to make great breakthroughs of the earthquake prediction in the short term, earthquake early warning is recognized as a technical method that can effectively reduce earthquake disasters in the world [1]. As early as 1868, the concept of Earthquake Early Warning (EEW) proposed by Dr. Cooper. He envisioned that seismic monitoring devices were deployed in the Hollister area, where the strong seismic activity was very strong at that time, about 100 kilometers away from San Francisco. After the earthquake, an electromagnetic signal would be generated. Since electromagnetic waves traveled much faster than seismic waves, an alarm bell on the municipal building could be knocked before the seismic waves arrived, then an earthquake alert was sent [2,3].

With the continuous development of seismic monitoring instruments, real-time data transmission technology, data analysis and processing methods, and computer technology, Cooper's vision has gradually become a reality, such as the UrEDAS (Urgent Earthquake Detection Alarm System) of Japan Railway [4,5], the SAS (Seismic Alert System) of Mexico [6], and the Elarms (Earthquake Alarm System) of USA [7], and so on.

Fujian Earthquake Agency has always adhere to scientific and technological innovation to lead the development, and strive to improve the ability of earthquake prevention and disaster reduction services. Fujian Earthquake Agency developed an EEW data processing system in Fujian in 2009 and
began online testing in November 2012. During this testing, the EEW system successfully processed several earthquakes in both the Fujian region and Taiwan. In February 2013, the EEW data processing system passed a test organized by the China Earthquake Administration. At present, the system can output the emergency earthquake information products such as the earthquake early warning 5-10 seconds after the trigger, the automatic earthquake quick report 1-3 minutes, and the rapid earthquake report in 3-5 minutes.

In 2014, Fujian Earthquake Agency organized technical team to launch the earthquake early warning information releasing work. In May 2018, the earthquake early warning information service was officially provided to the public through the “Fujian Earthquake Early Warning” mobile APP and the special terminal.

2. System design and implementation

2.1. System architecture
Earthquake early warning system usually includes station observation system, data processing system, information release system, and information service terminal, and so on, as shown in Figure 1. Network transmission system is used for data transmission and information exchange between various systems. At the same time, in order to ensure the stable operation of the system 7 * 24 hours, it is also necessary to run the operation support system.

![Earthquake early warning system architecture](image)

**Figure 1.** Earthquake early warning system architecture

2.2. Earthquake early warning time algorithm
It is assumed that the earthquake early warning information obtained by using a small amount of previous observation data: an earthquake with magnitude $M_0$ (predicted epicenter seismic intensity $I_0$) occurred at $(\theta_0, \varphi_0)$ at time $T_0$. The S-wave earthquake early warning time at time $T(\theta_1, \varphi_1)$ is

$$T_s = \frac{D}{V_s} - (T - T_0)$$

- $T_s$ is earthquake early system time.
- $D$ is the spatial distance (in km) between the epicenter $(\theta_0, \varphi_0)$ and the user's position $(\theta_1, \varphi_1)$.
- $V_s$ is the equivalent average speed of S-wave propagation (usually 3.55km / s is acceptable).
- $T$ is the current time.
- $T_0$ is the time of the earthquake.

The terminal updates the warning time every second.

2.3. Predictive seismic intensity algorithm
The predicted seismic intensity $I$ at $(\theta_1, \varphi_1)$ is
\[ I = I_0 - 4.0 \times \lg \left( \frac{D}{10} + 1.0 \right) \]  

- \( I \) is the predicted seismic intensity at user's position \((\theta_1, \phi_1)\).
- \( I_0 \) is the predicted epicenter seismic intensity.
- \( D \) is the spatial distance (in km) between the epicenter \((\theta_0, \phi_0)\) and the user's position \((\theta_1, \phi_1)\).

2.4. Terminal response

Based on the local predicted seismic intensity \( I \) from formula (2), the terminal judges the level of the EEW warning and sounds and lights alarm with different levels, as shown in Table 1.

| Local predicted seismic intensity \( I \) | EEW levels | EEW colors |
|-----------------------------------------|------------|------------|
| 3 \leq I < 4                            | Level IV   | Blue       |
| 4 \leq I < 6                            | Level III  | Yellow     |
| 6 \leq I < 8                            | Level II   | Orange     |
| I \geq 8                                | Level I    | Red        |

3. Instance

At 5:28 on August 8, 2019, a magnitude 6.4 earthquake occurred in the sea area of Yilan county, Taiwan (24.52W, 121.96E) with the depth of 30 kilometers, as shown in Figure 2. The earthquake caused a strong shock on the entire island of Taiwan, and some high-rise buildings in the coastal areas of Fujian had a significant shock.

Fujian Earthquake Agency released an earthquake early warning message at 26 seconds after the earthquake. The predicted seismic intensity of the Pingtan Comprehensive Experimental Area, Putian, Fuzhou, Quanzhou, Ningde, Xiamen, and Zhangzhou city in Fujian Province was 3 degrees. It won the early warning time of 30 seconds to 81 seconds for all parts of Fujian Province. In this earthquake, the
Fujian Earthquake Early Warning Information release Platform provided earthquake early warning information services for 70,000 mobile phone users and 5,898 sets of earthquake warning information receiving terminals.

Figure 3 shows the response of the "Fujian Earthquake Early Warning" APP on the iOS platform to the earthquake. The magnitude of the earthquake given by the earthquake warning is 6.1. The main reason that it is different from the final earthquake magnitude is that the earthquake warning information is only calculated by using a small amount of seismic wave information in the previous period.

![Figure 3. Screenshot of APP in response to earthquake](image)

4. Conclusion and discussion
The Fujian Earthquake Agency's emergency earthquake information release platform provides earthquake early warning information services to the public through the “Fujian Earthquake Early Warning” mobile APP and a dedicated receiving terminal.

According to the EEW information release standards of local predicted seismic intensity exceeding 3 degrees or earthquakes over magnitude 5.5 in Taiwan and the Taiwan Strait, from May 2018 to December 31, 2019, Fujian Earthquake Agency released warning information to the public in law of earthquake M6.2(November 26, 2018, Taiwan Strait), earthquake M5.7( April 3, 2019,Taidong County), earthquake M6.7 (April 18, 2019, the sea area of Hualien County), earthquake M5.8(June 4, 2019, the sea area of Taidong County), and earthquake M6.4 (August 8, 2019, the sea area of Yilan County).

The "Fujian Earthquake Early Warning" mobile APP based on the Android platform needs to maintain a long-term connection with the earthquake early warning information publishing platform in order to provide earthquake early warning information services normally. In the hibernation state, the corresponding power and network traffic will be consumed, and the security management software...
will recognize it as malicious software and force it to shut down, resulting in failure to provide users with earthquake warning information services.

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