A General Introduction of the Earthquake Early Warning System in Wenchuan, China

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SUMMARY
Since Wenchuan earthquake in 2008, a dramatic progress on EEW has been made by Institute of Care-life (ICL). The research on EEW by ICL covers sensing, ideas of installing the stations, analysis of the seismic waves for EEW, application of EEW messages for both students and some life-line projects, such as high speed trains. So far, over 130 EEW alerts have been triggered, and thus tested, by actual earthquakes. Indeed, the EEW alert has triggered the evacuation of students in a school in 2011. Indeed, innovative work is done to suppress false alarm and miss alarm, to initiate the move of delivering EEW messages to the public, to push the application of EEW in China.

Keyword: Early Warning, Wenchuan

1. GENERAL INTRODUCTIONS

The 2011 March 11th earthquake of 9.0 Mw has demonstrated the great effects of earthquake early warning (EEW) system for emergent stopping the high trains, as well as providing about 60 seconds for people in Tokyo. This, of course, followed many successful applications of EEW since Oct. 1st, 2007 in Japan.

Actually, much research has been done worldwide mostly since the 1960s. In particular, the researchers in USA [Allen] and in China [Peng, Ma, Wang] have made many dramatic progresses. Specifically, scientists in China started to work on EEW around 2003 or so. For example, a few years ago, a prototype EEW system in the Beijing capital region [Peng] was developed and over 139 earthquakes have triggered the system. But that system has only been limited to internal tests, i.e., basically only the researcher themselves get the trial EEW messages. However, a dramatic progress is made by a new research group on EEW, Institute of Care-life (Chengdu). This fresh institute was initiated only after the 2008 Wenchuan 8.0 magnitude earthquake. In this paper, we will summarize some major progresses of our institute.

2. SOME MAJOR RESULTS

The EEW system developed by ICL has been deployed into the Wenchuan area, covering about 20,000 kilometers squared (see Fig.1). Parts of Sichuan, Ganshu, Shanxi provinces are covered. This area corresponds to the major devastated area by the Wenchuan earthquake and has many aftershocks. Up to now, 102 stations (for examples see Fig.2) are deployed into the area. Each station includes an acceleration sensor, a data acquisition part, and data process part, and communication part, etc.

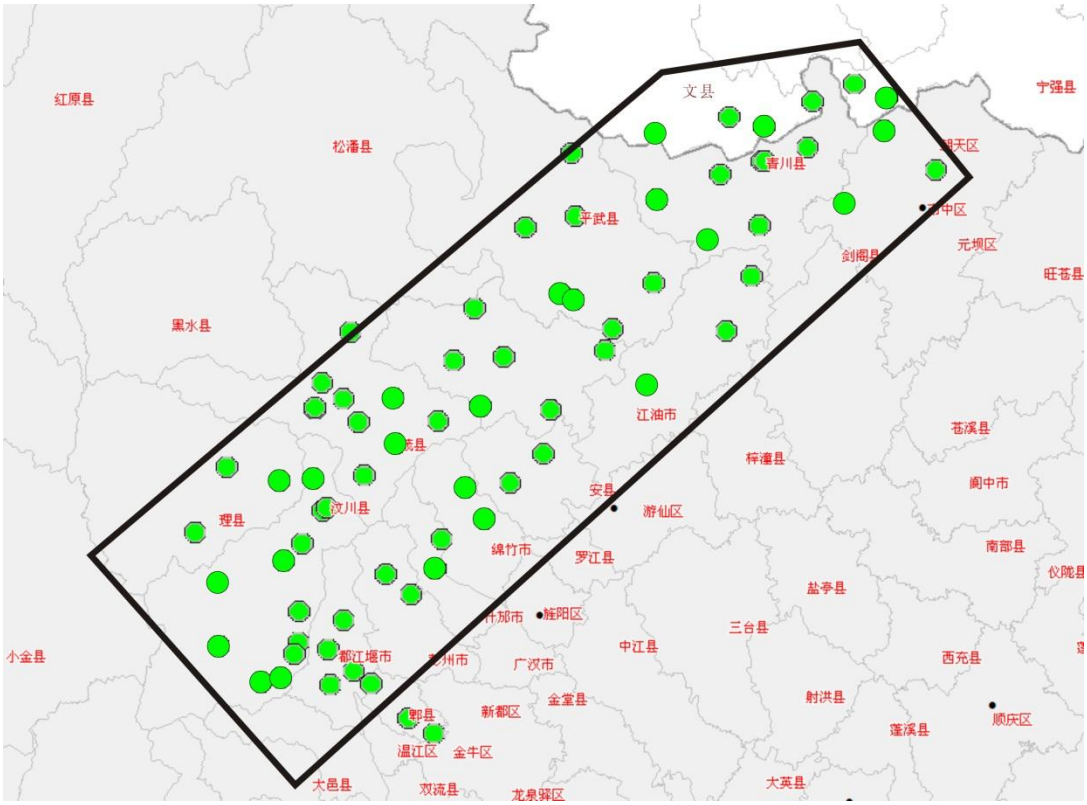

Figure 1. The Wenchuan area (marked by dark lines) for the EEW system.
The blue dots mean the stations. Note that for clarity, not all stations are drawn in the figure.

Figure 2 . The pictures of two stations.
On the left panel, the station is in an independent shield, and on the right panel, the station is inside a quilt room. Note that the sensor, data acquisition, communication, etc. are all integrated in station.

After about 3 years of research and development, ICL deployed its system to the Wenchuan area. Since April 19th, 2011, the Wenchuan EEW system began in operation. Since June 7th, 2011, the system began to show stability: the rate of false alarm is less than 1%. And over 120 alerts have been delivered by April 30th, 2012. And the alerts were triggered by earthquakes of magnitude from 0.4 to 5.4.

Many reasons explain the stability of the system: intelligent algorithms are used to prevent false alarms. Detailed description of the algorithms will be presented elsewhere.

The EEW system can not have mitigation effects unless the EEW messages are actually delivered to the public. Considering most Chinese people do not know, or never heard of, the EEW before, it is difficult and unsafe to deliver EEW messages to them. The people have to be educated first and then the law can be made.

To find the right people to educate, we begin to deliver the EEW messages to seismologists. And after their experience of EEW and then they have some basic idea how reliable the EEW can be, then they began to promote the idea of EEW to even more people and also suggest to deliver the messages to some people in the government and some selected public.

By "selected public", we mean people who want to receive the EEW messages have to apply an account from our institute first. Only after an endorsement by our institute, can he or she begin to receive EEW messages. By doing this we have initially got over 1200 volunteers from more than 20 provinces in China to receive the EEW messages. These volunteers share the information of the presence of EEW with other people, so more and more people get educated on EEW. In fact, with the advertisement of the 1200 people, about 20,000 people have begun to use the EEW. Most of them are students in elementary schools and middle schools.

For the students, after training, they can respond to actual earthquakes. Fig. 3 shows the actual evacuation of students after they heard an EEW alert. Note that the students started to evacuate without any guidance by their teachers at the time of EEW.

Figure 3. The actual evacuation of students in Jiangyou Shuanghe middle school in Sichuan province after they heard an EEW alert on Dec. 6, 2011.

With the development of technologies, EEW messages can now be delivered through internet and cell phone network, and the receivers can be computer, cell phones, and specialized receivers (Fig. 4). So far, cell phones with operation of Windows, Android, and IOS can receive instant EEW messages. For the purpose of more people to experience EEW, SMS is also used to deliver EEW messages to many volunteers as this approach only requires the volunteers' cell phone numbers.

Figure 4. A picture of the specialized receiver for an EEW system.
It receives the EEW messages from IP network and/or cell phone network,
and then can automatically turn on the power of a broadcasting system for a broadcast of the alert.

With the number of people to receive EEW messages ever grows, the necessity to make guideline and laws on EEW is made more urgent than any time before. In particular, China has declared to deploy EEW system in the whole country. Considering EEW is more a technology for society than a technology for seismologists, some people are thinking of an EEW industry in China now.

3. SOME TECHNICAL DETAILS OF THE WENCHUAN EEW SYSTEM

The system includes basically three parts: the stations, the center, and the receivers. Each station has three functions: first, sensor to detect the seismic movements; second, data acquisition to transfer the analog data to digital data; third, extract some key parameters for the EEW; forth, send the data flow and the key parameters to the center. The key parameters include the arrival time of P and S waves, their polarizations, and Tc and Pd etc. for calculating the magnitude of the earthquakes.

The center collects the data flow and key parameters from all the stations, makes decision of whether an earthquake happens, determines the parameters of an earthquake, decide whether to deliver the alerts of the earthquake.

Then the receivers get the warning messages. An EEW message includes the location, magnitude, the start time of the earthquake and the count down time for the arrival time of S wave, the distance from the epicenter, and the estimated intensity at the site of receiver. The receivers can respond to the above information, in particular, the estimated intensity and the countdown time. And a general evacuation solution is provided by our institute.

4. CONCLUSION AND OUTLOOK

The research on EEW by ICL covers sensing, ideas of installing the stations, analysis of the seismic waves for EEW, application of EEW messages for both students and some life-line projects, such as high speed trains. Innovative work is done to suppress false alarm and miss alarm, to initiate the move of delivering EEW messages to the public, to push the application EEW in China.

We are now deploying more stations to Sichuan province to better serve the people. Note that the area of Sichuan province is even greater than that of Japan. We are anxious to expect of the project be done within 2012 and then to cover more parts of China.

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