Times-Standard
Times-Standard / Humboldt Beacon

Not My Fault: Earthquake early warning, dark fiber and MAMA

Lori Dengler/For the Times-Standard
Posted: December 20, 2017

The 2017 annual meeting of the American Geophysical Union just concluded. At over 62,000 members, AGU is the largest organization of earth scientists in the world and the annual meeting features cutting-edge presentations from many disciplines. I want to highlight two that focused on recording earthquakes.

There is nothing new about earthquake detection devices. Zhang Heng is credited with the first quake sensor nearly 2000 years ago in China. It featured a massive urn with eight dragons carrying small bronze balls delicately balanced in their mouths. Eight frogs were arranged around the base with mouths open to receive the balls. When shaking exceeded a certain level, balls were released to be caught by the frog below. It was a surprisingly sensitive device, capable of detecting quakes more than 100 miles away. Depending on which balls had fallen, officials could determine the direction the seismic waves had traveled from.

True seismographs, instruments that measure the ground motion as a function of time, were developed in the late 19th century. 1897 saw the first in the Western Hemisphere when Berkeley installed an instrument at the Lick Observatory. These early instruments were mechanical marvels, featuring large masses poised on springs and pendulums to effectively keep the core of the instrument stationary while all is shaking around it.

There aren't many of the early seismographs still functioning. But if you live on the North Coast, you are in luck. The Ferndale Museum features two Bosch-Omori horizontal seismographs that are still in prime working order, scratching out traces on smoked paper drums. These instruments, designed in 1906, operated at Mare Island in the Bay Area for 25 years before Berkeley moved them to the Ferndale Fire Station in 1933 where they were part of the Berkeley network for 47 years.

These first generation seismographs had limitations. Timing was awkward and required corrections several times a day. The magnification was controlled by the length between the mass and the display and limited to 100 to 1000 times the ground motion depending on size. And they had a limited range of frequencies and amplitudes they could record.

The springs and pendulums are gone in today's instruments. Most use a force-balance seismometer where very high-resolution displacement sensors measure the minute forces required to keep a mass level or stable. The magnitude of the stabilizing force is easily measured, and can be related to the ground motion. These are wonderful instruments, capable of recording tiny signals and very strong ones over a large range of frequencies and periods. And they are very expensive – a modern broadband sensor and data logger will cost upwards of $50,000 a pop.

Herein lies the rub. We need many more instruments in order to fully implement Earthquake Early Warning. Today's seismic network does a fine job of locating most regional earthquakes within a few minutes. That may sound pretty quick, but it's not nearly fast enough for effective EEW, which requires at least four sensors to pick up the first seismic waves within two seconds of the start of rupture in order to warn you that strong shaking is headed your way. That means about one seismic station every ten square miles. Southern California and parts of the SF Bay Area come close to this, but much of California including the North Coast are nowhere near this density. We would need about 20 more stations just in Humboldt County, a million dollar price tag not including installation and maintenance costs.

Enter some new ideas on how to record earthquakes. One of the papers at AGU described a novel seismic detection approach using 'dark fiber.' This was completely new to me. I knew nothing about the thousands of miles of abandoned unused fiber-optic cable in this country and hadn't a clue that could be used to detect earthquakes. Referred to as Distributed Acoustic Sensing (DAS), the method shoots a laser signal along the optic cable. Seismic waves deform the cable and causes distortions of the light that can be measured and be used to determine earthquake epicenters and direction of wave travel. In some urban areas like Sacramento, there are great piles of the stuff in the ground and this might provide inexpensive additional sensors.

No such luck in Humboldt where we have few optic cables. Perhaps MAMA will come to the rescue. MAMA stands for MEMS Accelerometers Mini-Array. You may not know of MEMS, but you probably own several. MEMS stands for 'microelectromechanical system', microscopic devices that sense environmental changes and process data. They are in smart phones, game controllers, drones, navigation systems and the list goes on and on. MEMS accelerometers are inexpensive (<$150) and about the size as a cell phone. Two factors are important in EEW – detecting the seismic signal and being able to tell the direction the waves are coming from. A single instrument won't work, but stringing a number together might be just the ticket.

Last spring we worked with Berkeley to install a 12-station MAMA array at HSU and it has already detected seven quakes. At the AGU meeting, Ran Noff who runs the project, was able to show that MAMA can effectively detect earthquakes of magnitude 3 and larger within 80 miles of the array at a fraction of the cost of a broadband seismograph. So maybe MAMA will be able to warn us after all.

Note: You can see the Ferndale seismographs any time during open hours at the Ferndale Museum and read about their background at http://www.ferndale-museum.org/seismo-cont.htm.

Lori Dengler is an emeritus professor of geology at Humboldt State University, an expert in tsunami and earthquake and co-author of "The Extraordinary Voyage of Kamome," proceeds from which support the Japanese-Crescent City student exchanges and outreach efforts. Questions or comments about earthquakes or this column can be sent to Kamome@humboldt.edu or (707) 826-6019.

http://www.times-standard.com/opinion/20171220/lori-dengler-earthquake-early-warning-systems-dark-fiber-and-mama