Gravity signals may provide a little extra warning before an earthquake strikes

Amina Khan, Los Angeles Times, 11-23-16

Earthquake early warning systems may be due for a gravity boost. Scientists studying Japan’s 2011 Tohoku earthquake say they’ve found a signal faster than seismic waves to tell when a temblor is on its way.

The method, described this week in the journal Nature Communications, involves tracking the subtle gravitational shifts that can occur immediately after the initial rupture, and could help researchers design faster and more powerful warning technologies.

“This new paper is the first [observational evidence] that this phenomenon really happens,” said study coauthor Jean Paul Ampuero, a Caltech seismologist. “This is important because of the doors it opens for early warning.”

When an earthquake begins, people might have only a few moments to prepare before the ground starts to shake. Seismic waves known as P waves — waves of compression and dilation that travel through the earth from the actual rupture — can, if detected, allow people a few crucial seconds or even minutes of preparation, depending on their distance from the epicenter. But while P waves travel fast (roughly 1 to 14 kilometers per second), their travel time still eats up some of that precious warning window.

Scientists have long thought they might be able to get an even quicker heads-up by looking at changes in the gravitational signal at the rupture event — changes caused as massive chunks of earth move, making various spots more or less dense and thus altering their gravitational tug. Because gravity propagates at the speed of light, this signal theoretically could provide a near-instantaneous way to detect an earthquake as soon as it starts, even at great distances from the epicenter.

The problem is that it’s very, very difficult to detect that gravitational signal amidst all the surrounding noise — including, for example, the rising and falling of the tides caused by the moon’s massive pull. In order to pick up such a signal, scientists would need to have a very powerful gravimeter close to a quake’s epicenter, with comparatively little noise that would drown the signal out.

The 2011 Tohoku earthquake provided just such an event. The magnitude 9.0 temblor, which triggered a massive tsunami that led to a meltdown at the Fukushima Daiichi nuclear power plant and resulted in the deaths of more than 15,000 people, happened about 510 kilometers from the Kamioka Observatory’s superconducting gravimeter, a very powerful instrument.

The scientists measured the signal hitting the Kamioka gravimeter approximately 65 seconds after the rupture event — about nine seconds before the seismic waves even arrived. Sure enough, after removing all the noise, they found a gravitational shift emanating from the event some 510 kilometers away — thus proving that such detections were possible.

For this study, the scientists chose to look 65 seconds after rupture in order to get a strong reading, since the gravity signal started out weak but grew in strength. Ideally, future instruments will be sensitive enough to detect ruptures perhaps five seconds after they occur. Depending on a person’s distance from the epicenter, the signal could provide precious extra moments to prepare.

“In Japan, for example, they could gain more than 20 seconds for any earthquake warning happening offshore,” Ampuero said.

The few seconds afforded to those close to a rupture might not seem like much. But, if linked to automated safety systems, the added time could still mitigate the damage caused by a quake. Even with just five or 10 seconds to spare, programs that would stop a train, an elevator or heavy machinery could kick in, Ampuero said.

Of course, deploying a network of highly sensitive gravimeters will require a whole new generation of powerful, sensitive technologies that have yet to be developed, he said. Building them will probably take several years.

“We’re working with other teams who have developed sensors for other applications but have pieces of the technology that will be useful for this,” he said. “And if we had the funding to do it right now ... in three years we would have a proof of concept of many of the key technologies, and perhaps in five years we [would have] a pilot sensor.”

Seismologist Susan Hough of the U.S. Geological Survey in Pasadena, who was not involved in the study, expressed some skepticism that the findings would result in a practical tool.

“It's definitely cool science, but I don't see any hope that gravity [measurements] will improve early warning significantly,” she said.

Even if it travels at the speed of light, the gravity signal has to be generated by fault movement — and for a big earthquake, that movement takes a while, Hough said.

“For effective early warning, you can't wait for an earthquake to get big,” she added. “The trick is to figure out quickly after it starts that it's going to get big.”