Times Standard

Not My Fault: Earthquake prediction around the corner? Maybe….

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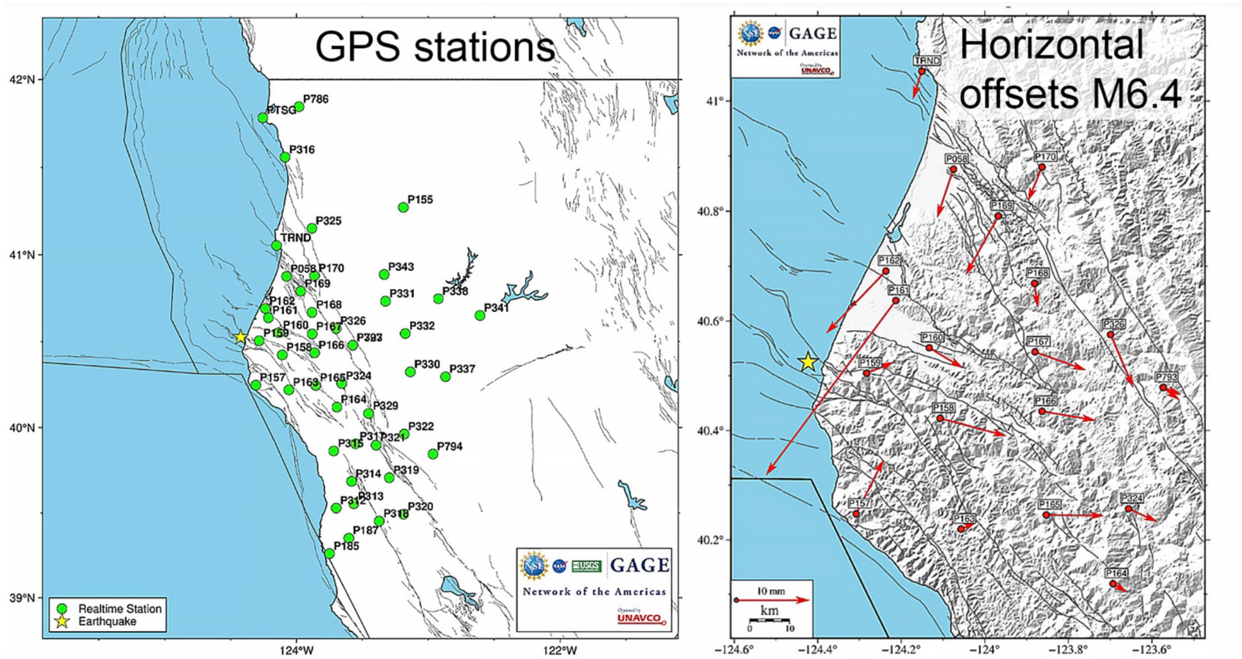

Global Positioning Satellite (GPS) network (left) and displacements recorded AFTER (right) the December 20, 2022 earthquake. The maximum displacements are less than 5 inches. This existing system is not adequate to record the far smaller signals that may have preceded the earthquake. Images from Earthscope.

I will likely get a text alert before the next strong North Coast earthquake. The ShakeAlert system is based on detecting fault rupture in the first second or two AFTER it begins and relaying text messages to expect shaking. If I am more than 15 to 20 miles away from the epicenter, I hope to get a few second heads up to expect shaking.

ShakeAlert is NOT earthquake prediction. It kicks into action only after the earthquake rupture has begun. Mexico was the first country in the world to recognize that quick detection of an earthquake once it had started could save the lives of people further away.

Mexico had good reason to get into the early alerting world. In 1985 a magnitude 8 earthquake struck off the coast over 200 miles away from Mexico City. There was some damage in communities near the epicenter, but the bulk of the damage was in Mexico City where an estimated 10,000 deaths occurred. Mexican seismologists and officials reasoned that detecting the earthquake as it ruptured on the coast could give Mexico City residents as much as 30 to 40 seconds before the seismic waves reached the City.

Japan quickly followed Mexico's lead in earthquake alerts. With the densest network of seismographs in the world, Japanese residents are now used to getting cell phones texts that shaking is expected in the next few seconds. California launched the first US early alerting system in 2019 that has now expanded to all the Pacific states.

Many of you have received earthquake alerts. The system has been tested on the North Coast more frequently than any other part of the State. We have more earthquakes that meet the criteria for alerts – magnitude of 4.5 for MyShake, 5.0 for USGS Wireless Emergency Alerts and moderate shaking strength. But as many of you learned on December 20th, getting the alert at the same time the earthquake shaking is waking you up is not very useful. Many people have asked – why can't we have more time?

What if we could get more than a few seconds of alert time? Maybe minutes or tens of minutes? A paper published in Science last July suggest that for some earthquakes, it MAY be possible. French researchers Bletery and Nocquet suggest that the Global Positioning Satellite System (GPS) might provide as much as two hours of warning before large earthquakes. I emphasize the "may" as we've got a long way to go before the method is validated and becomes established.

We rely on GPS to drive, find our lost phones and pets, and follow the whereabouts of teenagers. The GPS we use is only accurate to a few tens of feet – good enough for our needs. This isn't nearly accurate enough for scientific applications where we need to measure down to fractions of an inch. In the early days this meant a laborious process of establishing monuments and measuring/remeasuring those monument sites over hours.

GPS is now standard procedure in studying large earthquakes. But until the 2000s, they were not done in real time. Monument sites were established, and revisited at monthly, yearly, or longer intervals to record how the locations had changed. GPS campaigns were labor intensive as they required scientists to visit each monument and spend several hours carefully gathering the data and only a few real time networks were in place.

The 2011 Great East Japan Earthquake gave a jolt to the GPS world. Japan's seismic network is the densest and most sophisticated in the world but yielded an initial magnitude estimate of 7.8, far below the 9.1 that hours later it was determined to be. Underestimating magnitude has consequences. It meant that the initial tsunami estimates were far smaller than what was actually produced.

Japan's GPS network showed the true scale of the earthquake but weren't used in real-time assessment of magnitude or part of the early warning protocol at the time. This earthquake demonstrated the need for continuous GPS, instruments that are in constant contact with the GPS satellite network and, at 5 second intervals, send data to a repository. These new systems are called GNSS (Global Navigation Satellite Systems) and are capable of providing earthquake information as it is happening, just like a seismograph. US seismic networks now use it as well.

Bletery and Nocquet are pushing the GPS envelope a step further. They argue that the faults that produce very large earthquakes begin to deform (precursory slip) before the main fault rupture initiates. They studied 90 earthquakes of magnitude 7 and larger over the past decade by looking at the GPS signals in the 48 hours before the earthquake occurred.

The team saw no deviation from the normal background level until about two hours before the quake. But in that two-hour window, about half of their sample showed a small anomalous signal that accelerated just before the fault snapped. To verify that what they saw was real, they looked at 100,000 random 48-hour time series where no magnitude 7 quakes had occurred. This control group found almost no anomalies.

The findings are intriguing. People have been looking for a true earthquake precursor for centuries and it has been elusive. A number of seismologists have looked at the precursory slip paper with interest and point out some problems. This study looked at earthquakes of the past – we knew when and where they were and so the GPS data could be preselected for that window. It would be a much more difficult task to monitor the whole globe in real time to target anomalies before they occur.

We are a long way from GPS anomalies becoming actionable earthquake precursors. Other scientific teams will now be analyzing the GPS data sets to see if the results can be replicated. We need more and higher precision GPS instruments and improved methods of real-time scanning and analysis. While a 50% success rate sounds promising, it really isn't something you can act on. The societal implications of a "warning" that half the time is false is a recipe for chaos.

Last December's M6.4 was detected on the regional GPS network. Stations to the south of the rupture were displaced four or five inches to the east while stations to the north generally moved to the south. This deformation helps to understand the fault slip. But this network wasn't capable of seeing any anomalies beforehand; the earthquake was too small. The methodology also won't work for offshore quakes as no comprehensive GPS network sits on the seafloor.

I am excited to see how GPS precursory slip pans out. Could it have made a difference last February when magnitude 7.8 and 7.5 earthquakes tore through Southern Turkey? And if an alert had been issued, how would people in Turkey and Syria received the information and responded? Much more work lies ahead not only for seismologists but also social scientists.

Reference: "The precursory phase of large earthquakes" by Quentin Bletery and Jean-Mathieu Nocquet, 20 July 2023, Science. DOI: 10.1126/science.adg2565

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