Gravity sensors might offer earlier warning of earthquakes

November 23 2016, by Bob Yirka

Ruins from the 1906 San Francisco earthquake, remembered as one of the worst natural disasters in United States history. Credit: Public Domain

(Phys.org)—A team of researchers from France, the U.S. and Italy has found evidence from the Tohoku-Oki earthquake that sensors that measure changes in gravity might offer a way to warn people of impending disaster faster than traditional methods. In their paper published in the journal *Nature Communications*, the group describes how they analyzed data from gravity sensors near the epicenter of the Tohoku-Oki quake back in 2011 and found that it was possible to isolate gravitational changes due to the earthquake from the noise of other events.

Current earthquake warning systems rely on a network of seismic sensors—they listen for P-waves below the ground which are generated by an earthquake and send a signal to an alarm if they are heard. Such a system offers those in the vicinity of a quake from a few seconds to perhaps a minute to take safety measures. In this new effort, the researches wondered if it might be possible to detect subtle changes in gravity measurements near the epicenter of a quake to offer those in harm's way a little more time to prepare for it—because gravity waves travel at the speed of light.

Prior research has shown that there are subtle changes in gravitational pull around the epicenter of a quake, due to changes in the density of the rock in the area. But until now, it was not clear if such changes could be picked out from all the other background noise. To find out, the researchers pulled data from gravimeter sensors located approximately 500 kilometers from the epicenter of the Tohoku-Oki quake and compared what they found in the record with data from five seismic stations in the same area. They noted also that it took 65 seconds for the P-waves to reach the seismic stations. To find out if the quake data would stand out amongst the noise of other natural events (such as the changing tides) the team looked at measurements taken over the 60 days prior to the quake and then at the data from the day before, the day of, and the day after the quake. In looking at the data, the researchers found that they were able to "see" a small blip—one that stood out enough to confirm a quake had occurred.

More research will have to be done before it can be proven that a network of gravity sensors would truly offer people more time to prepare for a quake (depending on how close they are to the epicenter), but the results from this initial study seem promising.

More information: Jean-Paul Montagner et al. Prompt gravity signal induced by the 2011 Tohoku-Oki earthquake, *Nature Communications* (2016). DOI: 10.1038/ncomms13349

Abstract
Transient gravity changes are expected to occur at all distances during an earthquake rupture, even before the arrival of seismic waves. Here we report on the search of such a prompt gravity signal in data recorded by a superconducting gravimeter and broadband seismometers during the 2011 Mw 9.0 Tohoku-Oki earthquake. During the earthquake rupture, a signal exceeding the background noise is observed with a statistical significance higher than 99% and an amplitude of a fraction of μGal, consistent in sign and order of magnitude with theoretical predictions from a first-order model. While prompt gravity signal detection with state-of-the-art gravimeters and seismometers is challenged by background seismic noise, its robust detection with gravity gradiometers under development could open new directions in earthquake seismology, and overcome fundamental limitations of current earthquake early-warning systems imposed by the propagation speed of seismic waves.

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