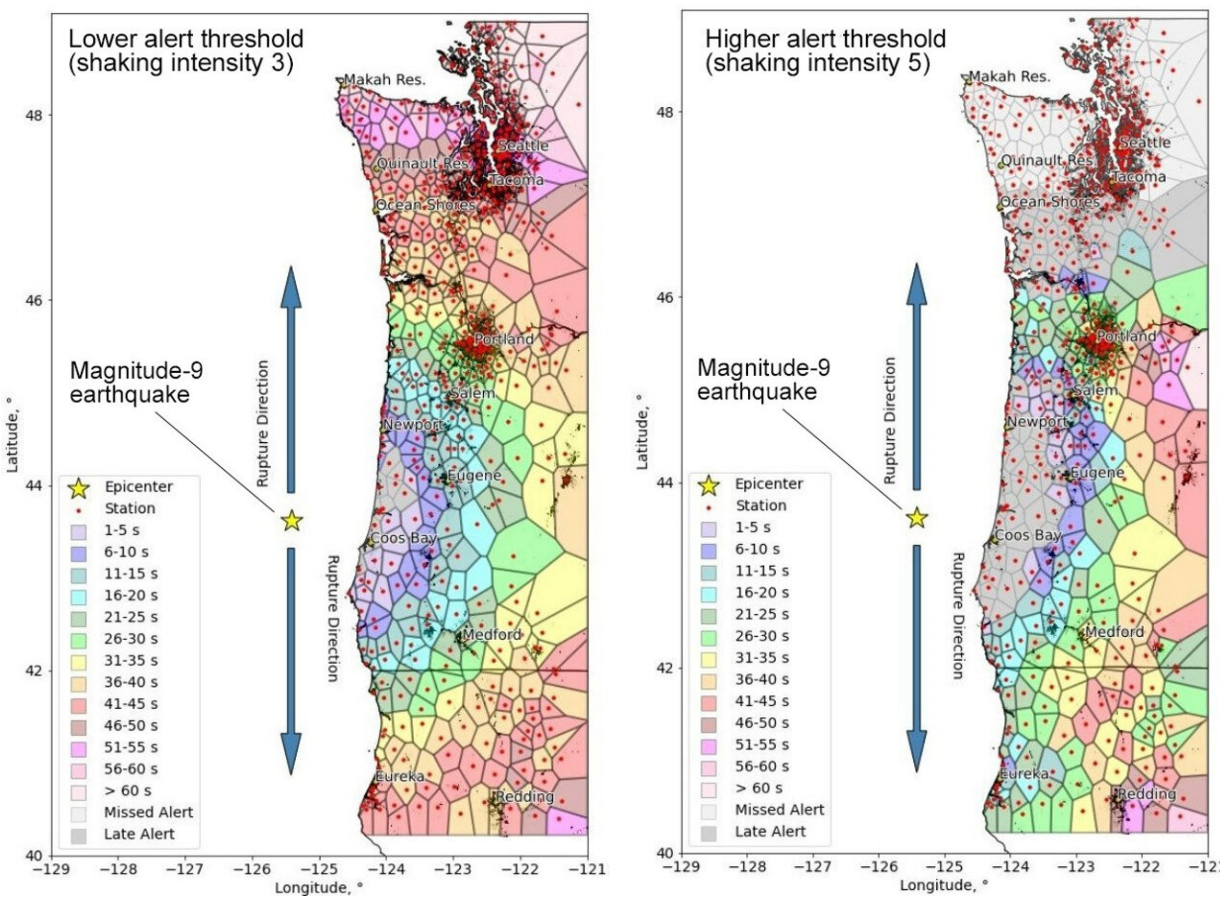
Simulations show how earthquake early warning might be improved for magnitude-9 earthquakes

December 8 2021, by Hannah Hickey



Earthquake early warning times for a magnitude-9 event with an epicenter in southern Oregon. With a lower alert threshold (left) some locations closest to the source feel the ground shake before the alert arrives (late alert, pictured in dark gray). For a higher alert threshold set only to warn of moderate shaking (right) a larger region close to the source feels the ground shake before the alert arrives (dark gray), and most of Washington state has either a missed alert or a late alert. Researchers suggest that lowering the alert threshold, from intensity-5 to intensity-3 or -4, would help to improve the alerts' performance for offshore earthquakes. Black patches on the maps are highly populated areas, and red dots are seismic stations. Credit: Mika Thompson/University of Washington

When the next major earthquake hits the Pacific Northwest, a system launched last spring should give some advance warning, as emergency alerts go out and cell phones buzz. But how well the system functions might depend on whether that quake is the so-called "really big one," and where it starts.

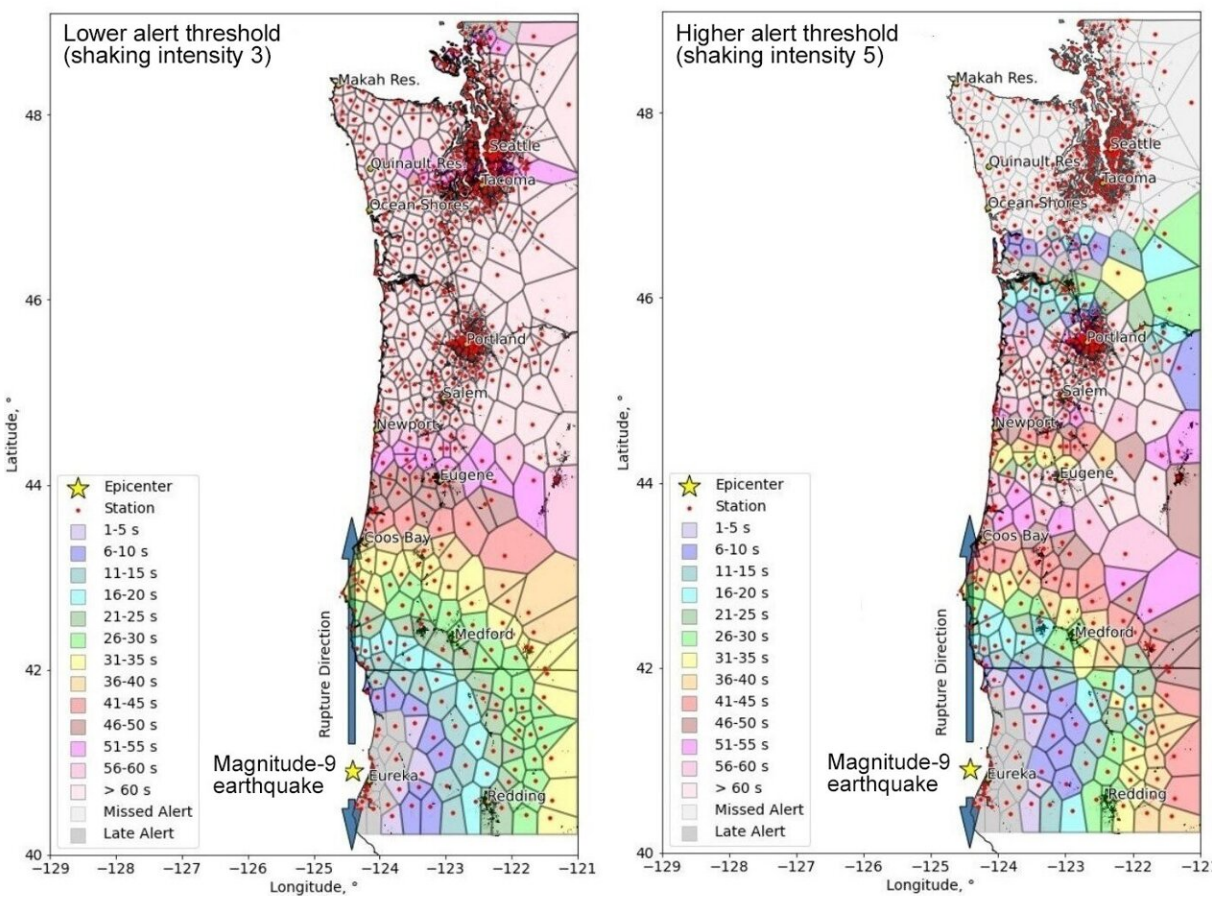
The Pacific Northwest's last magnitude-9 event from the offshore subduction zone was in 1700. Only a few clues remain about how it unfolded. But with the earthquake early warning system being built out and improved, seismologists want to know how ShakeAlert would do if the really big one were to happen today.

A research project by the University of Washington and the U.S. Geological Survey uses simulations of different magnitude-9 slips on the Cascadia fault to evaluate how the ShakeAlert system would perform in 30 possible scenarios. Results show the alerts generally work well, but suggests ways the system could be improved for some of these highest-risk events.

The research will be presented Dec. 13 as an online poster at the American Geophysical Union's annual fall meeting, being held as a hybrid event based in New Orleans.

"I've experienced both the Loma Prieta and the Nisqually earthquakes, and both times my first thought was: 'Is this really happening?'" said lead author Mika Thompson, a UW doctoral student in Earth and space sciences. "An early warning system gives people a moment to collect their thoughts and prepare to react. That's especially important for a major earthquake."

The work used detailed computer simulations of magnitude-9 earthquakes created for a previous study looking at how a big offshore event would play out, depending on where and how deep the Cascadia tectonic fault slipped. Thompson played those simulations through an off-line version of the ShakeAlert system and calculated the alerts that would go out across the region.



Earthquake early warning times for a magnitude-9 event with an epicenter in

Northern California. With a lower alert threshold (left) locations closest to the source feel the ground shake before the alert arrives (late alert, pictured in dark gray) while large regions have more than a minute of warning (pink). For a higher alert threshold set to only warn of moderate shaking (right) a larger region close to the source feels the ground shake before the alert arrives (dark gray), and most of Washington state has a missed alert. Researchers suggest that lowering the alert threshold, from intensity-5 to intensity-3 or -4, would help to improve the alerts' performance for offshore earthquakes. Black patches on the maps are highly populated areas, and red dots are seismic stations. Credit: Mika Thompson/University of Washington

"The alerts are generally doing well, but they're not perfect," said co-author Renate Hartog, manager at the UW-based Pacific Northwest Seismic Network. "This project is trying to understand the system's limitations so that we can make recommendations for future alerting strategies."

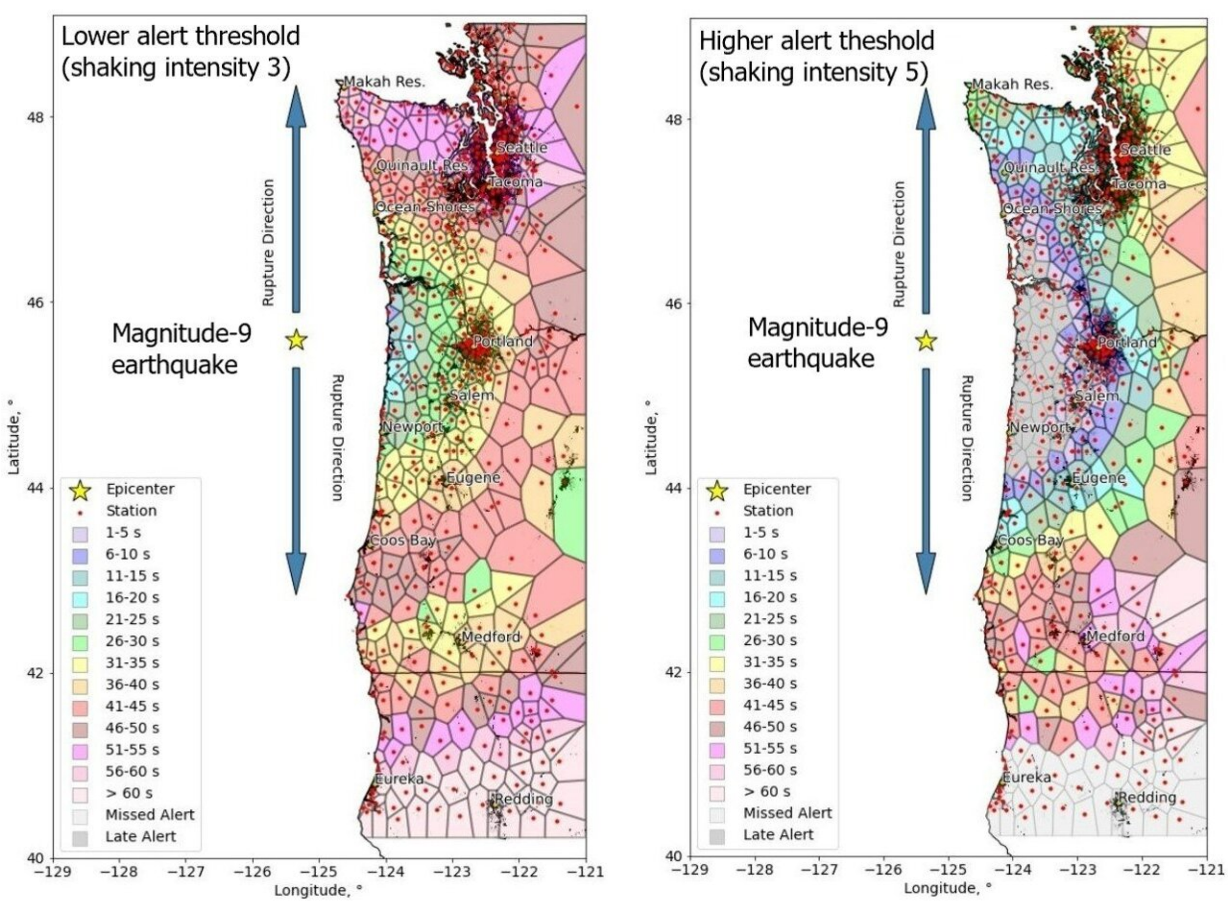
The alerts performed well even though big offshore earthquakes are harder for the system to detect and locate. But there were cases in which a warning arrived too late to some areas.

For instance, when the simulated rupture started at the southern end of the fault, the initial estimate for places far away, like Seattle, were sometimes below the shaking intensity level 5 threshold to generate an immediate alert. As the slip moved northward the shaking increased, but at this point the alerts arrived too late in Seattle to give ample warning time for level-5 and higher levels of shaking in that area.

"Magnitude-9 events are challenging because the alerts are being generated as the seismic event continues to unfold," Thompson said. "The Nisqually earthquake was a magnitude-6.8 and lasted only about six seconds. But a magnitude-9 earthquake could take more than five minutes for the whole rupture to occur."

One solution for this uncertainty, which Hartog says is in some ways unavoidable, might be for users to lower their threshold for alerts to shaking intensity 3 or 4. Users might get alerts for some minor events, but they would also have better odds of being alerted to a magnitude-9 earthquake—even if the slipping started far away.

"For the scenario that starts in Northern California, if the threshold is set to shaking intensity-3 then everyone in the West Coast ShakeAlert region is alerted, and some people can get warning times of up to one minute," Thompson said. "But if you use a higher intensity-5 threshold, you'll see smaller alerting regions that will have missed alerts on the outer edges."



Earthquake early warning times for a magnitude-9 event with an epicenter in northern Oregon. With a lower alert threshold (left) everyone gets some warning time. For a higher alert threshold (right) locations closest to the rupture feel the ground shake before the alert arrives (late alert, pictured dark gray) and parts of northern California get no alert (missed alert, pictured light gray). Researchers suggest that lowering the alert threshold, from intensity-5 to intensity-3 or -4, would improve the alerts' performance for offshore earthquakes. Black patches on the maps are highly populated areas, and red dots are seismic stations. Credit: Mika Thompson/University of Washington

In the case of a rupture starting in southern Oregon or Northern California, the entire Seattle-Tacoma region would miss alerts at the higher threshold. Apps, expected to arrive soon in Washington state, will allow users to set their own alert thresholds.

"What is the cost of taking action when it is not necessary, versus not taking action when it is necessary? It just depends on each individual situation, and that's how people should decide how to set the threshold," Hartog said.

Installing seismic sensors on the seafloor directly over the offshore fault would be another way to improve the alerts, especially for coastal communities.

Final results will be analyzed and shared with the full West Coast ShakeAlert community to determine whether and how to adjust the system's warning algorithms.

"The ShakeAlert system is constantly evolving. The algorithms are being tuned, our networks are still being built out," Hartog said. "It's not a static system, it's still actively being improved."

Also involved in this work is Erin Wirth, a research scientist at the U.S. Geological Survey and a UW affiliate faculty member in Earth and space sciences. The research was funded by the U.S. Geological Survey.

More information: Paper/presentation: agu.confex.com/agu/fm21/meetin … app.cgi/Paper/899109

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