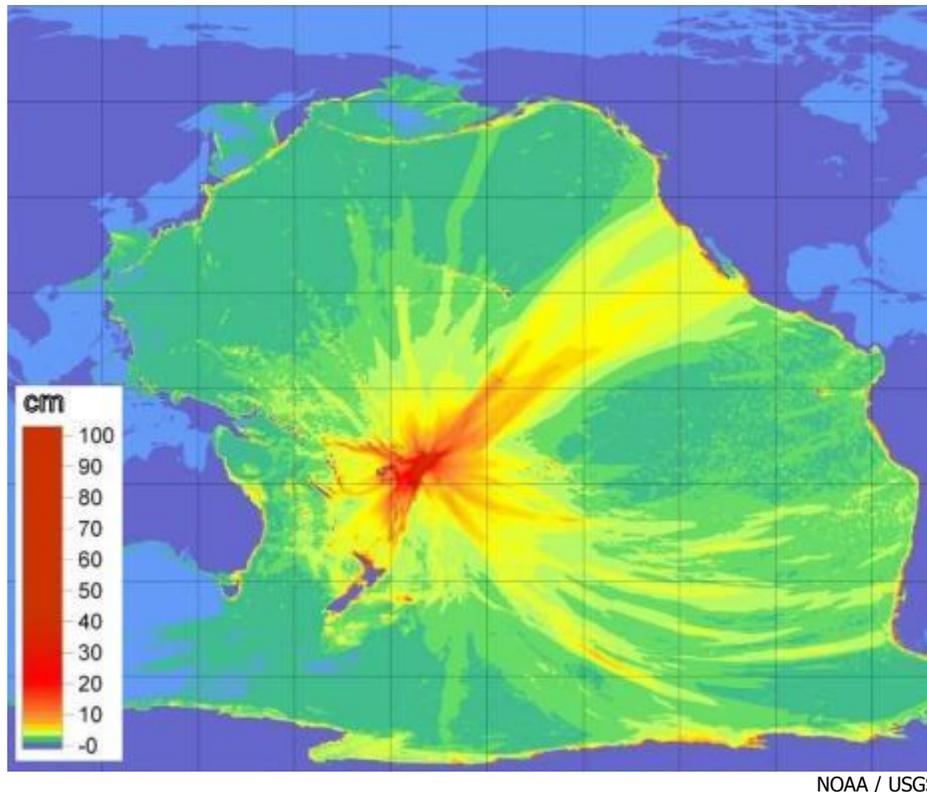


# How wave warnings work

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This color-coded map models how high waves rose in the wake of the Samoa Islands earthquake. The color key is calibrated in centimeters above sea level.

Five years after a catastrophic Indian Ocean quake pointed up serious shortcomings in the world's tsunami warning network, a beefed-up monitoring system worked quickly to sound the alarm about [this week's undersea shocks](#) in the Pacific, seismologists say.

The tsunami alarm may not have gotten out quickly enough to avoid the [loss of life in Samoa](#), and there are still gaps in the system. Nevertheless, this week's response demonstrated how much things have changed since 2004.

"It's night and day," Stuart Weinstein, deputy director of the National Oceanic and Atmospheric Administration's [Pacific Tsunami Warning Center](#) in Hawaii, told me today. "So much more has transpired in the intervening five years."

The best news about the past five years is that the network of sensors watching for seismic and ocean activity has expanded dramatically. Satellite communication systems pass along readings from those sensors every 15 minutes or less.

"Back in 2004, when the Sumatran disaster struck, there were only four instruments in the Indian Ocean that were transmitting their data and making it available in near real time," Weinstein said. "Now there are over 50."

Back then, about 20 seismometers around the Pacific Rim were watching for earthquake activity. "Now, typically, we're bringing in well over 200 seismic stations from around the world," Weinstein said.

Paul Whitmore, director of NOAA's [West Coast and Alaska Tsunami Warning Center](#) in Alaska, said the network also receives data from about 400 tide gauges around the world. "Five years ago, it was less than half that, and the data was often delayed one to three hours," he said.

### **15-minute warning**

This week, the center in Hawaii sent out its first tsunami bulletin just 15 minutes after the first signs of the magnitude-8.0 South Pacific quake were detected. That's a dramatic change from the hours that were required to get a good fix on the magnitude of the 2004 quake and tsunami. But it still wasn't soon enough for Samoa, which was already being hit by tsunami waves rising as high as 20 feet (6 meters) by the time the bulletin was issued.

The system's performance varied from agency to agency. A warning system run by the European-backed [Global Security and Crisis Management Unit](#) reportedly failed to evaluate the tsunami's impact in real time due to a hardware failure. Tsunami-watchers in Australia and New Zealand, meanwhile, said that their warning systems [worked well](#).

The impact of tsunami waves can vary dramatically, depending on the direction and depth of a seismic fault as well as the nature of the underwater terrain. The South Pacific quake had such an effect on Samoa because the most powerful waves radiated in that direction - and strangely enough, America's West Coast was another directional target.

The West Coast and Alaska Tsunami Warning Center could see those waves coming, and Whitmore said an appropriate advisory was issued for Californians and Oregonians.

"We didn't need them to be evacuating, and we didn't want them to be doing nothing," he told me. "Our estimates were a little bit high, but I believe the emergency management systems that I'm familiar with took the right action in keeping people out of the harbors."

Whitmore said the center's bulletin estimated that waves could be 4 to 25 inches (10 to 65 centimeters) above sea level. The actual maximum wave heights were 1.4 feet (42 centimeters, in Arena Cove, Calif.). The timing estimate for the waves' arrival, about 11 hours after the quake, was "very good," Whitmore said.

The Pacific center had yet another potential threat to assess just hours after the tragedy in Samoa. When today's magnitude-7.6 quake hit western Indonesia, experts had to decide quickly whether a tsunami might follow. "We were not expecting a destructive wave, but sometimes you can't tell," Weinstein said. So a regional tsunami watch was sent out 10 minutes after the quake was detected.

According to reports from the scene, fears of a tsunami caused thousands of people to flee the Sumatran coastal city of Padang in panic. But it turned out that no giant waves were generated, and the tsunami watch was canceled 65 minutes after it was issued.

### **Far from perfect**

Tsunami-watchers admit that the warning system is still far from perfect. "While we have come a long way in five years, there's still a lot of analysis yet to be gained," Whitmore said.

Forecasters rely on computer models to take the data from widely spread sensors and figure out which way the waves are heading. And the models are constantly being tweaked to reflect real-life events such as this week's shocks. "That's going to be an ongoing, never-ending battle," Whitmore acknowledged.

There's also a serious issue relating to maintenance of the sensor network: Just three months ago, Public Employees for Environmental Responsibility [issued a report](#) pointing to what it said were "gaping holes" in the tsunami warning system. NOAA's records indicate that 10 out of its 39 deep-ocean pressure monitoring stations, also known as DART buoys, were failing. Still more deep-ocean sensors operated by other countries are on the blink.

Weinstein noted that neither of NOAA's two DART buoys in the Indian Ocean are currently functioning - which certainly didn't help when it came time to assess the impact of today's Indonesia quake. "They probably need to be checked out," Weinstein told me.

The important thing is for folks in coastal communities to [be prepared](#) - even before authorities sound the alarm.

"If you feel an earthquake, get to high ground as fast as you can," John Bellini, a geophysicist with the National Earthquake Information Center in Denver, told [Inside Science News Service](#). "Five minutes was not enough time for emergency services to move into action. It is hard to get a warning out faster than five minutes, so people have to know to move to higher ground."