Updated May 2019

PNSN

Pacific Northwest Seismic Network

About The PNSN

The Pacific Northwest Seismic Network (PNSN) provides information about earthquakes to emergency responders, the press, and public. The PNSN works to reduce risk by monitoring ground motion and distributing information, primarily through pnsn.org. Beginning in 1969 with five seismic stations, the network has expanded to over 400 stations throughout Washington (WA) and Oregon (OR). This makes the PNSN the second largest seismic network in the US.

The PNSN is a cooperative project between the University of Washington (UW), the University of Oregon (UO), and the US Geological Survey (USGS). The PNSN is headquartered at UW in the Earth and Space Sciences Department and has staff in Richland WA, Vancouver WA, and Eugene OR at UO in the Department of Earth Science. Primary support for the PNSN comes from the USGS, the State of Washington, the State of Oregon, and the US Department of Energy.

To learn more, visit pnsn.org or email pnsn@uw.edu.

The PNSN's monitoring stations. Each station has sensors that measure ground motion.

PNW Earthquakes

Crustal Earthquakes

Caused By: Movement along shallow faults within the North American tectonic plate caused by compressional, extensional, or transform stress.
How often? Recurrence time varies by fault; in general, hundreds to thousands of years.
Where? Throughout WA and OR.

Volcanic Earthquakes

Caused By: Movement of magma near volcanoes.
How often? There is variation throughout the Cascade Range. Increasing frequency and magnitude may precede volcanic unrest.
Where? Within 10 km (6 mi) of volcanoes.

Subduction Zone Earthquakes

Caused By: Slip on the plate boundary between the North American Plate and the subducting Juan de Fuca Plate.
How often? M8+ roughly every 300–500 years.
Where? Offshore, from northern CA to Vancouver Island, BC.

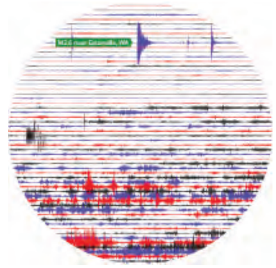
Deep Earthquakes

Caused By: Movement on faults within the subducting Juan de Fuca plate.
How often? Approximately every 30–50 years.
Where? At depths greater than 40 km (25 mi) under the I-5 corridor.

PNSN Data & Products

Recent Earthquakes

A map of recent earthquakes is available at pnsn.org/earthquakes/recent. The map is updated with waveforms and technical data within minutes of an event.

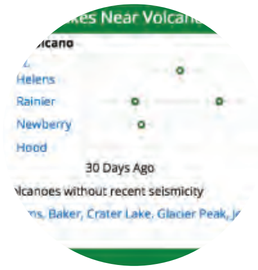


Real-Time Waveforms

Near real-time waveform displays from our seismic instruments are available at pnsn.org/seismograms, 24 hours a day, and are updated every 2 minutes.

Did You Feel It?

The USGS displays human reports of shaking on maps. Report your earthquake experience and see the map of shaking reports.

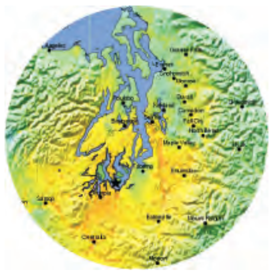


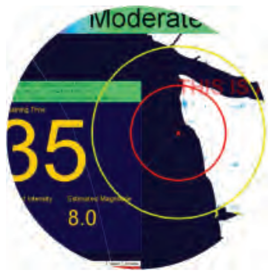
Volcanic Seismicity

Updates on earthquake activity at Washington's and Oregon's active volcanoes can be found at pnsn.org/volcanoes.

ShakeMap

The USGS measures shaking intensity. The map portrays the geographic extent and amount of shaking for post-earthquake situational awareness.





Earthquake Early Warning (ShakeAlert)

Real-time detection and measurement of earthquakes provides seconds to minutes of warning. This program is being developed by the USGS with the support of UW, UO, Caltech, and UC Berkeley.

Outreach

Educational programs for school groups, the press, and public groups are hosted at the Seismology Lab. The latest scientific information on earthquakes, volcanoes and the hazards they pose are covered in these programs.

Tremor Map

Tremor locations are displayed on an interactive map on pnsn.org/tremor. Tremors are too slight to feel and related to slow slip that can last up to multiple weeks.

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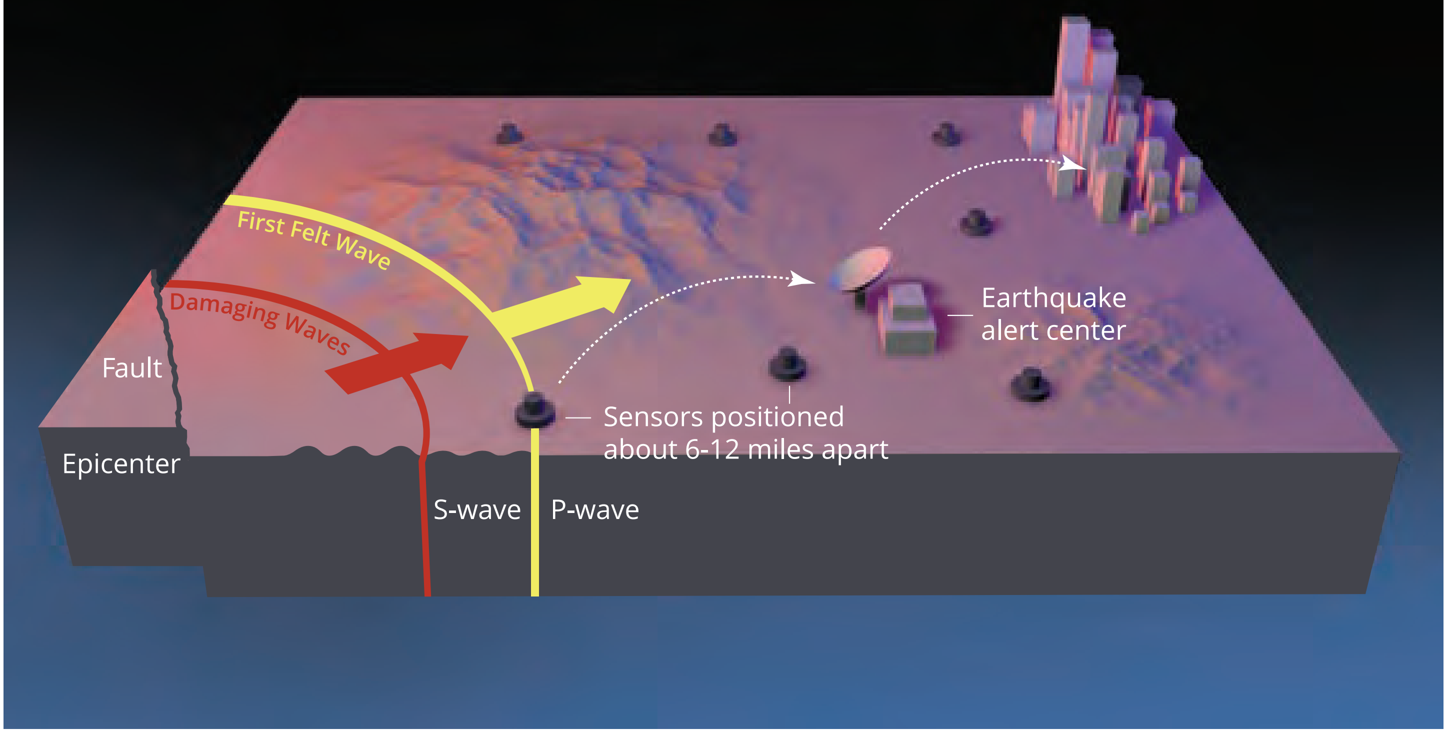
@PNSN1

ShakeAlert Call to Action



What is ShakeAlert?

ShakeAlert is a multi-state Earthquake Early Warning (EEW) system operated by the United States Geological Survey (USGS). It detects significant earthquakes very quickly and issues alerts that will reach many people before shaking arrives. When you receive a ShakeAlert, you should immediately take protective action such as "Drop, Cover and Hold On!". Do not wait to feel the shaking. ShakeAlert warnings provide many positive impacts such as:

Saving Lives

Reducing Economic Impact

Speeding Recovery

What Threat does ShakeAlert Address?

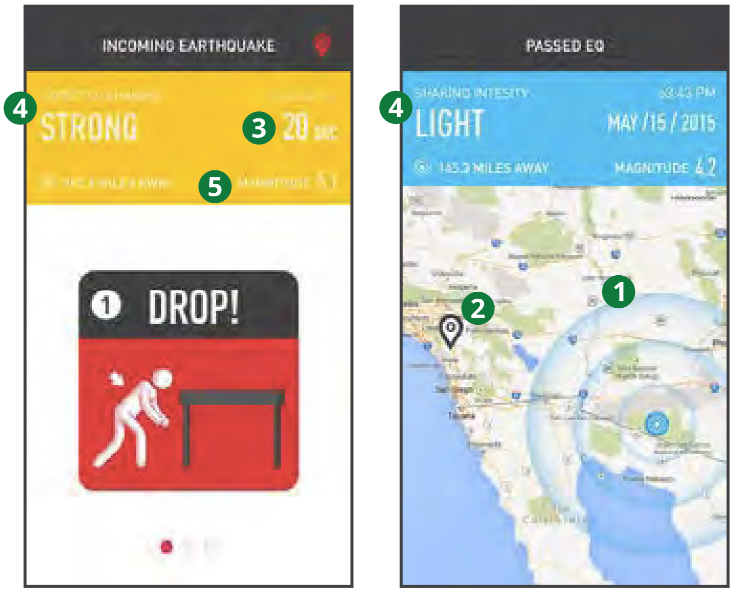
Fifty million residents in the three west coast states are likely to experience strong ground shaking from earthquakes within their lifetime. When ShakeAlert public alerting begins, these people will receive brief, but significant, warning in advance of shaking from magnitude 5 and larger earthquakes. In the Pacific Northwest three types of earthquakes can cause significant shaking and serious property and infrastructure damage.

Earthquake Type	Potential Magnitude	Chief Hazards	Estimated Economic Loss (Billions of US $)
Cascadia Subduction Zone	9+	• Strong shaking for several seconds to minutes • Major tsunami inundation • Widespread liquefaction • Widespread transportation and communication disruption • Aftershocks	$100B
Deep Earthquakes	~7	• Strong shaking for several seconds • Liquefaction • Some infrastructure damage	$1B to $4B
Shallow Crustal Earthquakes	7+	• Strong shaking • Liquefaction • Infrastructure damage • Aftershocks	$0.4B

Some ShakeAlert Basics

EEW systems currently operate in several countries (Mexico, Japan, Romania, etc.). The technology uses a network of seismic stations and geodetic stations that stream data in realtime to an alerting center. The PNSN, located at the University of Washington, is the alerting center for Washington (WA) and Oregon (OR). ShakeAlert continuously scans the data to detect P-waves from an earthquake as the rupture starts and progresses. ShakeAlert then estimates the magnitude and epicenter of the earthquake and forecasts the intensity and timing of strong shaking from S-waves that radiate outward.

The alerts are delivered through high-speed networks that initiate pre-programmed actions and generate alarms to protect recipients and critical processes. Typically, more distant locations will have more time to act but will experience less intense shaking.



ShakeAlert LA Mobile App

1 Radiating seismic waves from quakes epicenter

2 Users current location set by user

3 Seconds remaining before seismic waves reach user

4 Expected intensity of quake at users current location

5 Estimated magnitude of quake

Examples of ShakeAlert Uses

EEW will provide critical information that will save many lives, prevent injuries and speed recovery. Some examples:

- Users and automatic systems can initiate actions to protect themselves, equipment, and delicate operations from injury or damage from shaking. An alert could be received tens of seconds prior to strong shaking.
- The USGS will generate the alerts and delivery will come by other public and private means (internet, radio, television, cellular). These will include FEMA's Integrated Public Alert and Warning System (IPAWS).
- Transportation agencies will eventually be able to alert motorists and close down bridges, and in doing so, save lives.

Current Status & Planned Scope

The PNSN is seeking the assistance of concerned residents, businesses, and agencies to help improve and complete the current prototype system. The seismic network infrastructure required by the ShakeAlert system is today about half built and only about half funded in the Pacific Northwest. While only partially completed, the system is providing useful alerts to a few dozen "pilot users". These projects can use the warnings to take protective actions. For example, engineering companies can use the ShakeAlert signal to automatically control valves in water supply systems for several communities. This ensures that water will be available to fight fires and provide drinking water in the aftermath of an earthquake.

While the current system provides some protection, the completed system will improve the warning times and add robustness. The USGS has estimated that annual operations and maintenance of the network when complete will be $28.6 million per year. The ShakeAlert system is a partnership that combines the financial support and coordinates the activities of the US government, Washington, Oregon, California, and private enterprise.

Partnerships & Funding

In OR and WA, ShakeAlert is operated by USGS in cooperation with the Pacific Northwest Seismic Network. Funding for its development was to date provided primarily by the USGS, Cal OES, the State of Oregon and the Gordon and Betty Moore Foundation.

BE PREPARED FOR AN EARTHQUAKE

FEMA
FEMA V-1003/May 2018

Earthquakes can collapse buildings and cause heavy items to fall, resulting in injuries and property damage.

Earthquakes are the sudden, rapid shaking of the earth, caused by the breaking and shifting of underground rock.

- Can happen anywhere. Higher risk areas are California, Alaska, and the Mississippi Valley
- Give no warning
- Cause fires and damage roads
- Cause tsunamis, landslides, and avalanches

IF AN EARTHQUAKE HAPPENS, PROTECT YOURSELF RIGHT AWAY

- If in a vehicle, pull over and stop.
- If in bed, stay there.
- If outdoors, stay outdoors.
- Do not get in a doorway.
- Do not run outside.

HOW TO STAY SAFE
WHEN AN EARTHQUAKE THREATENS

Prepare NOW

Secure items such as televisions and objects that hang on walls. Store heavy and breakable objects on low shelves.

Practice Drop, Cover, and Hold On with family and coworkers. Drop to your hands and knees. Cover your head and neck with your arms. Crawl only as far as needed to reach cover from falling materials. Hold on to any sturdy furniture until the shaking stops.

Create a family emergency communication plan that has an out-of-state contact. Plan where to meet if you get separated.

Make a supply kit that includes enough food and water for at least three days, a flashlight, a fire extinguisher, and a whistle. Consider each person's specific needs, including medication. Do not forget the needs of pets. Have extra batteries and charging devices for phones and other critical equipment.

Consider earthquake insurance policies. Standard homeowner's insurance does not cover earthquake damage.

Consider a retrofit of your building if it has structural issues that make it vulnerable to collapse during an earthquake.

Survive DURING

Drop, Cover, and Hold On like you practiced. Drop to your hands and knees. Cover your head and neck with your arms. Hold on to any sturdy furniture until the shaking stops. Crawl only if you can reach better cover without going through an area with more debris.

If in bed, stay there and cover your head and neck with a pillow.

If inside, stay there until the shaking stops. DO NOT run outside.

If in a vehicle, stop in a clear area that is away from buildings, trees, overpasses, underpasses, or utility wires.

If you are in a high-rise building, expect fire alarms and sprinklers to go off. Do not use elevators.

If near slopes, cliffs, or mountains, be alert for falling rocks and landslides.

Be Safe AFTER

Expect aftershocks to follow the largest shock of an earthquake sequence.

Check yourself for injury.

If in a damaged building, go outside and quickly move away from the building.

Do not enter damaged buildings.

If you are trapped, send a text or bang on a pipe or wall. Cover your mouth for protection and instead of shouting, use a whistle.

If you are in an area that may experience tsunamis, go inland or to higher ground immediately after the shaking stops.

Save phone calls for emergencies.

Wear sturdy shoes and work gloves.

Take an Active Role in Your Safety

Go to **Ready.gov** and search for **earthquake**. Download the **FEMA app** to get more information about preparing for an **earthquake**.

FEMA
FEMA V-1003
Catalog No. 17233-4

How Often Do Earthquakes Occur?

E&O
Advancing awareness and understanding of seismology & Earth science while inspiring careers in geophysics.

IRIS is a university research consortium dedicated to monitoring the Earth and exploring its interior through the collection and distribution of geophysical data.

IRIS programs contribute to scholarly research, education, earthquake hazard mitigation, and the verification of the Comprehensive Test Ban Treaty.

This figure was produced in cooperation with the US Geological Survey, and the University of Memphis

Support for IRIS comes from the National Science Foundation, other federal agencies, universities, and private foundations.

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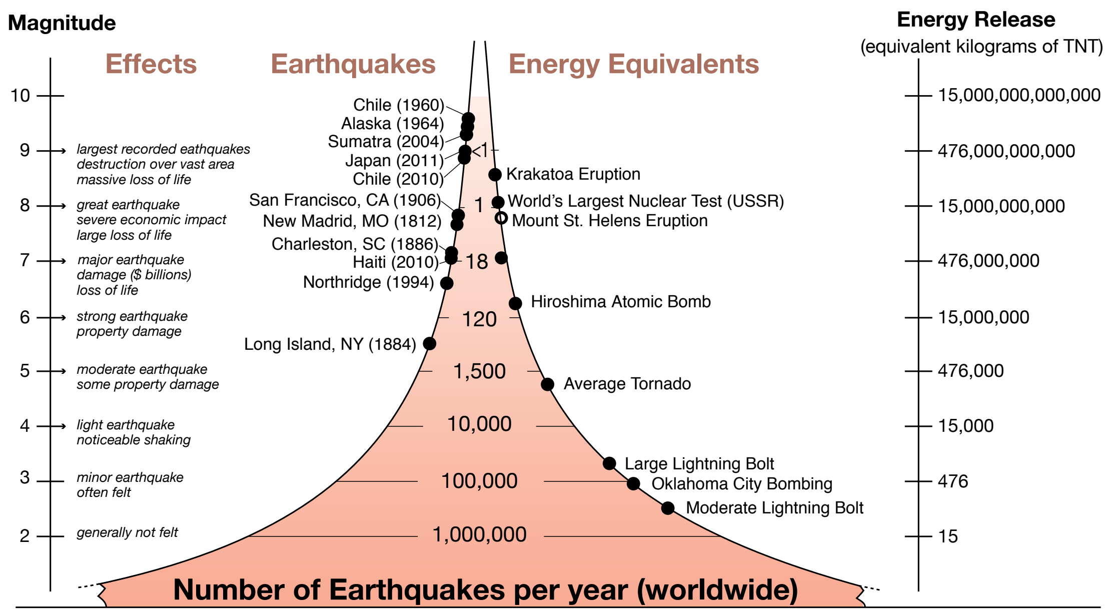
Earthquakes are always happening somewhere.

Magnitude 2 and smaller earthquakes occur several hundred times a day world wide. Major earthquakes, greater than magnitude 7, happen more than once per month. “Great earthquakes”, magnitude 8 and higher, occur about once a year.



The left side of the figure above describes the effects of an earthquake by magnitude. The larger the number, the bigger the earthquake. Significant earthquakes are noted on the left side of the shaded tower. The shaded area indicates how many earthquakes of each magnitude occur every year. The events on the right side of the tower show equivalent energy release.

The 2004 earthquake in Haiti, for example, was magnitude 7.0. Earthquakes this size occur about 20 times each year worldwide. Although the Haiti earthquake is considered moderate in size, it caused unprecedented devastation due to poor building material and construction techniques resulting in estimates of $11 billion to reconstruct. The earthquake released the energy equivalent to 476 million kilograms of explosive, about 100 times the amount of energy that was released by the atomic bomb that destroyed the city of Hiroshima during World War II.

The largest recorded earthquake was the Great Chilean Earthquake of May 22, 1960 which had a magnitude of 9.5. The great earthquake in 2004 in Sumatra, Indonesia measuring magnitude 9.1 produced tsunamis that caused widespread disaster in 14 countries. A magnitude 9.0 earthquake in Japan in 2011 also caused large tsunamis. All three were mega-thrust earthquakes on subduction-zone boundaries that, in a period of minutes, released centuries of accumulated strain and caused rebound in the overlying plates. Because great earthquakes release so much energy, the five largest earthquakes are responsible for half of the total energy released by all earthquakes in the last century.

Has earthquake activity been increasing?

There has definitely been an increase in the number of earthquakes that can be *detected and located* due to a more-than 10-fold increase in the number of seismic stations world wide over the past century. This doesn’t mean that the annual average number of earthquakes has increased. In fact, earthquakes of magnitude 7.0 and greater have remained relatively constant since record keeping began.

Although the average number of large earthquakes per year is fairly constant, they can occur in clusters. However, that does not imply that earthquakes that are distant in location, but close in time, are causally related. The NEIC locates about 12,000–14,000 earthquakes each year. Those records are reflected in the graph above.

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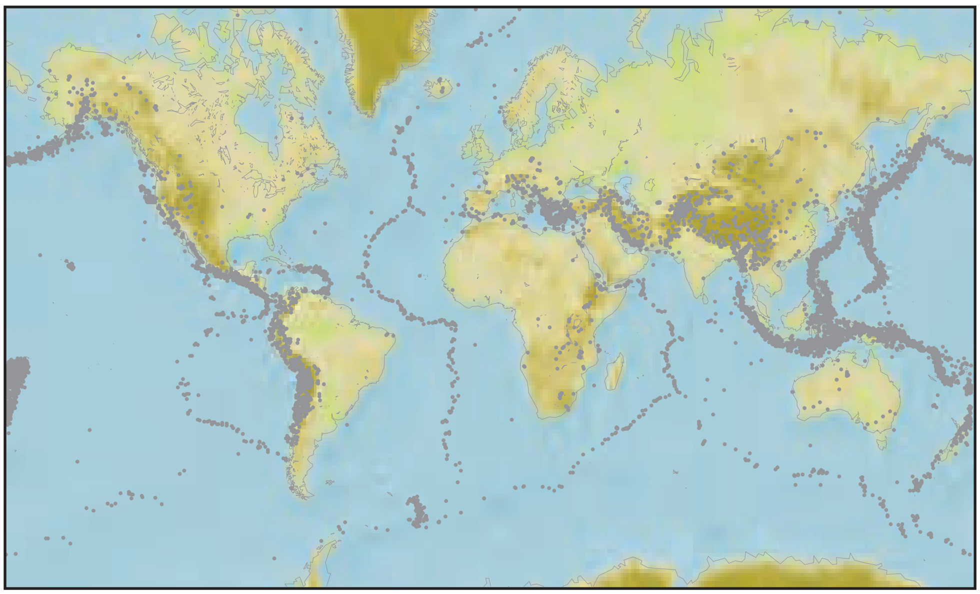
Why Do Earthquakes Happen?

You probably associate earthquakes with destruction caused by falling buildings or by the creation of a tsunami.

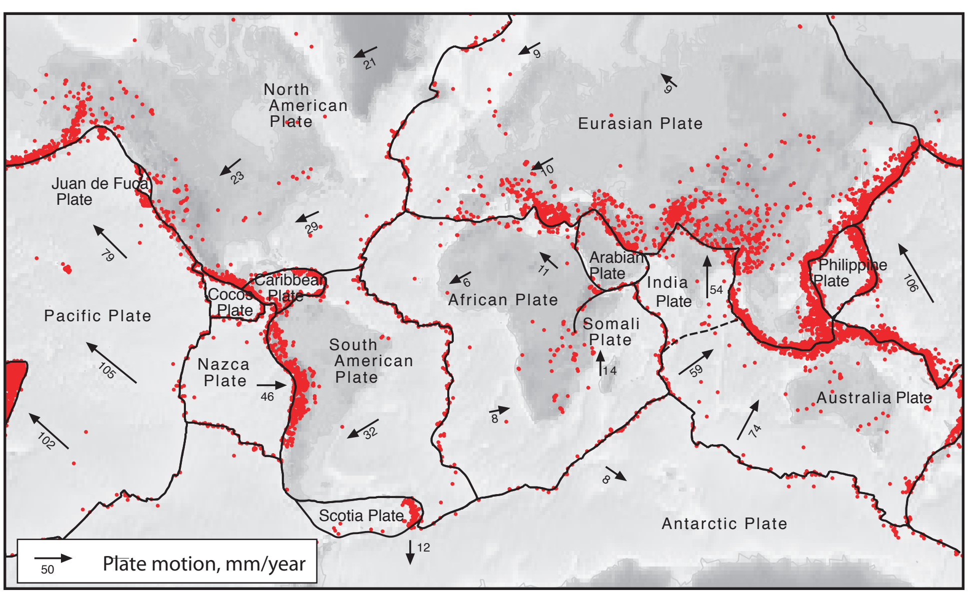
While earthquakes may be associated with destruction in the time frame of human activity, in the evolution of the Earth they signal the geological forces that build our mountains and create our oceans. In many ways, earthquakes are one of nature's reminders that we are living on the thin outer crust of a planet whose interior is still cooling.

Earthquakes happen when parts of Earth's crust move. Big earthquakes occur with movement of about a meter or two. Small earthquakes happen with movements of millimeters.

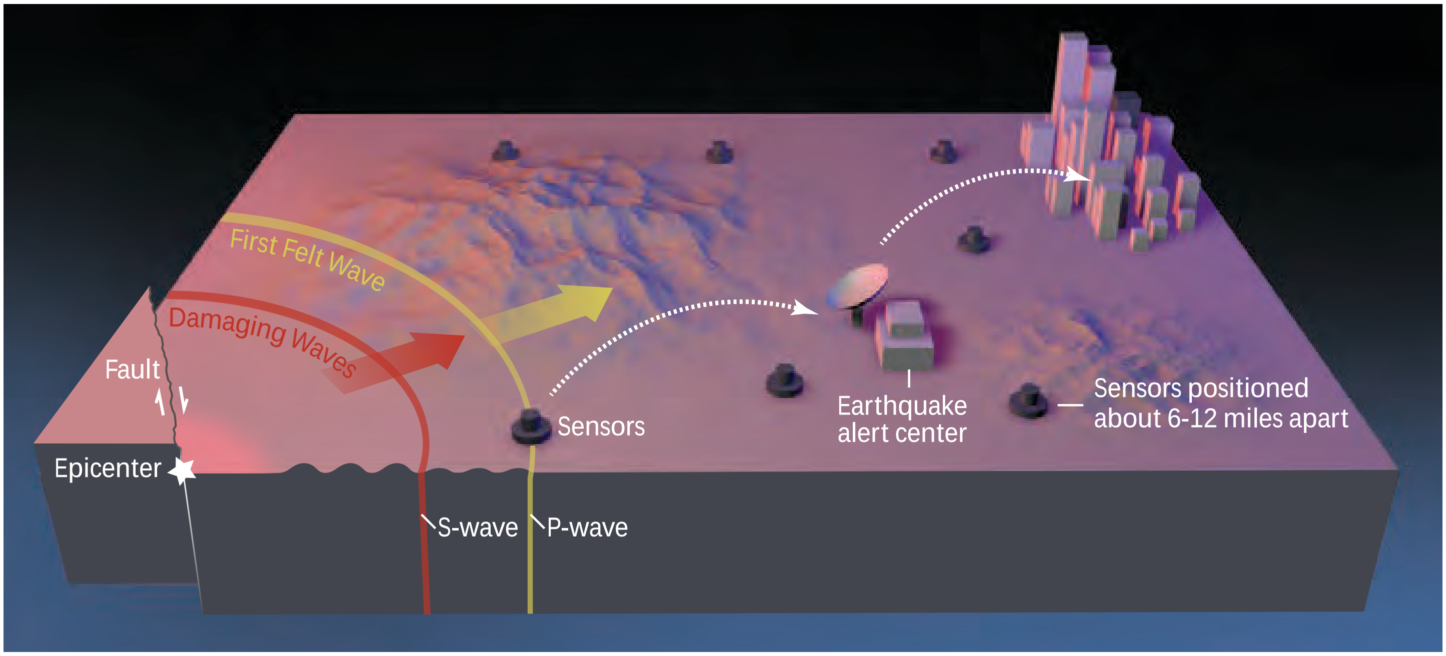
On the maps below, each dot marks the locations of a magnitude 4 or larger earthquake. The earthquakes were recorded over a five-year time period.



Earth's outer surface is broken into what geologists call plates. In general, earthquakes occur when plates move under, over, or slide past each other. As you can see on the map below, most earthquakes occur along the edges of the large plates that make up Earth's crust. The arrows on the map indicate how fast the plates are moving in millimeters per year—about as fast as your fingernails grow.



ShakeAlert—An Earthquake Early Warning System for the United States West Coast



Earthquake early warning systems like ShakeAlert work because the warning message can be transmitted almost instantaneously, while shaking waves from the earthquake travel through the Earth at speeds of a few miles per second. When an earthquake occurs, seismic waves—including compressional (P) waves, transverse (S) waves, and surface waves—radiate outward from the epicenter. The faster but weaker P waves trip nearby sensors, causing alert signals to be sent out, giving people and automated electronic systems some time (seconds to minutes) to take protective actions before the arrival of the slower but stronger S waves and surface waves. Computers and mobile phones receiving the alert message can calculate the expected arrival time and intensity of shaking at your location. USGS image created by Erin Burkett (USGS) and Jeff Goertzen (Orange County Register).

Earthquake early warning systems use earthquake science and the technology of monitoring systems to alert devices and people when shaking waves generated by an earthquake are expected to arrive at their location. The seconds to minutes of advance warning can allow people and systems to take actions to protect life and property from destructive shaking. The U.S. Geological Survey (USGS), in collaboration with several partners, has been working to develop an early warning system for the United States. ShakeAlert, a system currently under development, is designed to cover the West Coast States of California, Oregon, and Washington.

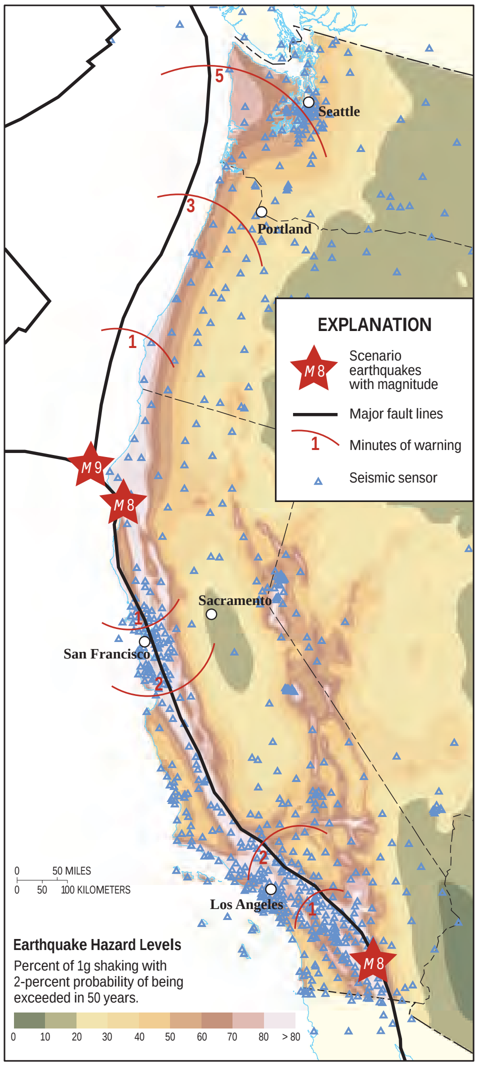
Earthquakes pose a serious risk to our Nation. According to the Federal Emergency Management Agency (FEMA), 77 percent of that risk, or an average annual loss of $4.1 billion, is concentrated on the West Coast in California, Oregon, and Washington (Federal Emergency Management Agency, 2008). Growing urbanization and increasing reliance on complex infrastructure for power, water, telecommunication, and transportation magnify that risk. An earthquake early warning system that can rapidly detect earthquakes and send alerts could prompt actions to protect life and property before strong shaking arrives. Development of such a system is a critical step toward offsetting physical risks, improving public understanding of earthquake hazards, and reducing fear of the unknown and unpredictable nature of earthquakes.

How Do Earthquakes and Early Warning Systems Work?

An earthquake occurs when a fault in the Earth's crust slips suddenly and the two sides move relative to one another. The rupture begins at one point on the fault and rapidly extends along some distance of the fault, like a lengthening crack in a car windshield. As the rupture travels along the fault, the sudden movement of the two sides of the fault generates seismic (shaking) waves that radiate outward through the Earth—much like ripples from a stone dropped in water. It is these waves that cause the ground shaking you can feel and the damage and destruction during earthquakes.

Although no one can predict earthquakes, the technology exists to provide warning to surrounding communities once a quake begins. This is done by an

Fact Sheet 2014–3083, version 1.2
February 2017



Map of the United States West Coast showing the amount of advance warning time that might be available from a system like ShakeAlert for several plausible future earthquake scenarios. Those scenarios include magnitude 8 (*M* 8) quakes on the San Andreas Fault with epicenters in northern and southern California and an *M* 9 quake on the Cascadia Subduction Zone with an epicenter offshore of northernmost California. Major population centers could have as much as several minutes warning before shaking waves from those quakes arrived. The map also shows the regional variation in the level of earthquake hazard in terms of the intensity of shaking (as a percentage of g, the acceleration of gravity) having at least a 2-percent probability of being exceeded in a 50-year period (from 2014 USGS hazard map). The network of seismic (earthquake) sensors is more concentrated near major faults and population centers. Illustration modified from Allen (2013).

earthquake early warning system, which rapidly detects seismic waves as an earthquake happens, calculates the maximum expected shaking, and sends alerts to electronic devices and people before damaging waves arrive. Early warning is possible because information can be sent through communication systems virtually instantaneously, whereas seismic waves travel through the shallow Earth at speeds ranging from 0.5 to 3 miles per second. This means that the shaking can take seconds or even minutes to travel from where the earthquake occurred to where you are.

Thus it is possible for automated systems or even your personal electronic devices, such as smartphones, to receive an alert before destructive shaking arrives. The USGS, in collaboration with State agencies, universities, and private companies, has been developing and testing ShakeAlert, an early warning system for the West Coast of the United States.

How Warning Can Increase Safety and Prevent Damage

Even a few seconds of warning can enable actions that protect people and property. In the time between receipt of an alert and arrival of damaging shaking, the following actions can be taken:

Human Responses

- Public–Citizens, including schoolchildren, Drop, Cover, and Hold On; turn off stoves; safely stop vehicles
- Businesses–Personnel move to safe locations
- Medical services–Surgeons, dentists, and others stop delicate procedures.
- Emergency responders–Open firehouse doors, personnel prepare and prioritize response decisions

Automated Responses

- Businesses–Open elevator doors, shut down production lines, secure chemicals, place sensitive equipment in a safe mode
- Transportation–Automatically slow or stop trains to prevent derailment
- Power infrastructure–Protect power stations and grid facilities from strong shaking

How Does ShakeAlert Work?

ShakeAlert has been in development since 2006 and began sending alerts to test users in California in January 2012 (see http://www.shakealert.org). The system detects earthquakes using our Nation's existing infrastructure for earthquake monitoring. The California Integrated Seismic Network (CISN) is a network of more than 400 high-quality ground motion sensors operated by the USGS in partnership with the State of California, California Institute of Technology, and University of California, Berkeley. The Pacific Northwest Seismic Network (PNSN) is a collaboration of the USGS, University of Washington, and University of Oregon. These regional networks are part of the Advanced National Seismic System (ANSS). ShakeAlert leverages and extends these networks' current research and post-earthquake response functions. When fully operational, ShakeAlert will be able to distribute alerts through all available distribution channels, including FEMA's Wireless Emergency Alerts (WEA) and Integrated Public Alert and Warning System (IPAWS), smartphone apps, social media providers, and other electronic alert technologies as they develop.

Test users of ShakeAlert currently receive alerts through a computer application with both audible and visual alert features. When ShakeAlert detects an earthquake, a map pops up on the user's screen to show the location of the earthquake epicenter (the point on the surface directly above the quake's starting point) and of waves moving toward the user; also shown is the time remaining until waves will reach the user's location and an estimate of the intensity of shaking. An alert sound alternates with a voice that counts down to the arrival time of seismic waves and announces the expected intensity.

How Much Warning is Possible?

An early warning system like ShakeAlert can provide seconds to minutes of warning before strong shaking arrives. The amount of warning time depends on the speed of the warning system and your distance from the epicenter.

An effective system requires a dense network of sensors to ensure that there are enough of them near all possible earthquake sources. Such a dense network can reduce the area near the epicenter for which reliable warning is not possible because the earthquake source is too close for an alert to outpace the seismic waves. The farther a location is from the epicenter, the greater the amount of warning time. To maximize warning time, the system must minimize delays in data processing, communication, and delivery of alerts.

Major Components of an Early Warning System

The ability to send adequate warning before shaking arrives requires the following:

- A network of sensors that are densely spaced and close to faults
- Quick and robust telecommunication from sensors to data processing centers
- Computer algorithms to quickly estimate an earthquake's location, magnitude, and fault rupture length, and to map resulting intensity
- Quick and reliable mass notifications
- End users educated in how to use the alerts

Future Developments

During its testing phase, ShakeAlert has detected thousands of earthquakes, including two that caused damage. The system began sending alerts within 4 seconds of the beginning of the *M*5.1 La Habra earthquake on March 28, 2014. ShakeAlert also sent alerts for the *M*6.0 South Napa earthquake on August 24, 2014, giving test users in Berkeley, California, 5 seconds of warning before shaking arrived.

Ongoing improvements to the sensor networks and data processing centers allowed the ShakeAlert system to advance from a "demonstration" to a "production prototype" phase in February 2016, allowing selected users to develop pilot implementations that take protective actions. USGS has published an implementation plan spelling out the steps needed to complete the system and begin issuing public alerts (Given and others, 2014). Public alerts and large-scale automatic implementation require additional development and further testing to make ShakeAlert sufficiently reliable (see sidebar "How Warning Can Increase Safety and Prevent Damage"), as well as end-user education on how to understand and use alerts.

The successful completion of the system will require the coordinated

Why ShakeAlert Emphasizes Intensity, not Magnitude

The shaking you feel is described by earthquake intensity rather than magnitude. High intensities are what cause damage in earthquakes.

Intensity

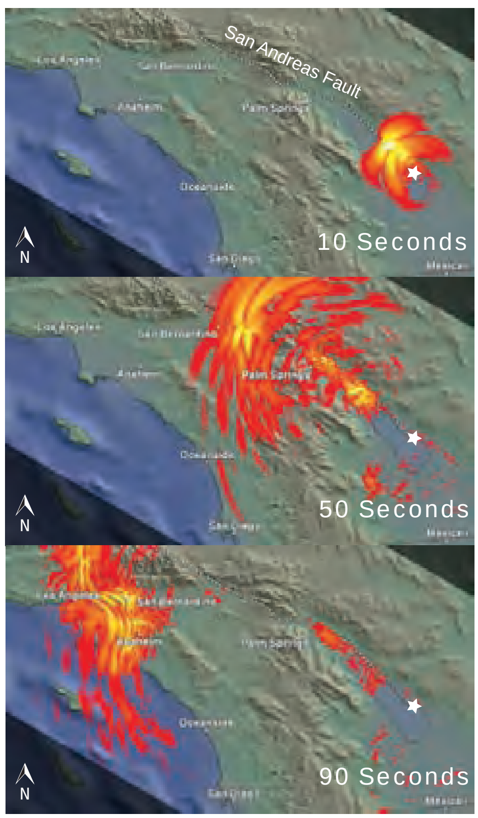
- Represents the level of shaking caused by earthquake waves at a particular location
- Depends on magnitude + distance + local geology
- Varies from place to place in a single earthquake

Magnitude

- Is one number representing the amount of energy released in an earthquake
- Depends on the size (surface area) of fault rupture

ShakeMaps (Wald and others, 2003) rapidly show the distribution of intensity after an earthquake (https://earthquake.usgs.gov/earthquakes/shakemap/).

You can also report the ground shaking you experienced to help create Did You Feel It? intensity maps (https://earthquake.usgs.gov/earthquakes/dyfi/).



Diagrammatic maps showing northwestward spreading of ground shaking (red and yellow) generated by the *M* 7.8 ShakeOut scenario earthquake centered in the Imperial Valley of southern California. The times shown are times after the start of the earthquake rupture at the epicenter (white star). This scenario was part of a comprehensive earthquake exercise conducted in the State of California in 2008 (Perry and others, 2008).

Will the West Coast have an Early Warning System Before or After the Next Big Quake?

Most countries with early warning systems built them after a devastating earthquake.

Japan invested $600 million in such a system after the 1995 Kobe earthquake killed 6,400 people. Today, Japan's system allows every citizen to receive advance alert of earthquake ground shaking from the Japan Meteorological Agency. Thanks to this system, no trains derailed in the 2011 magnitude 9.0 Tohoku earthquake, and according to a poll in Japan, 90 percent of the citizens think the system is worth the investment (Fujinawa and Noda, 2013).

Other countries that built systems after devastating earthquakes include

- China (after the 2008 Wenchuan earthquake killed 87,587 people)
- Taiwan (after the 1999 Chi Chi earthquake killed 2,415)
- Turkey (after the 1999 Izmit earthquake killed 17,127)
- Mexico (after the 1985 Mexico City earthquake killed 10,153)

efforts of government agencies at all levels, private companies, and the public. California has committed to developing earthquake early warning statewide, and companies are beginning to develop products to use and distribute the alerts.

The ongoing work of USGS scientists, together with partner organizations, on earthquake early warning systems is only part of the National Earthquake Hazard Reduction Program's efforts to safeguard lives and property from the future quakes that are certain to strike along the West Coast and other areas of the United States.

On your screen: ShakeAlert

1. Real-time tracking of seismic waves from quake's epicenter
2. Real-time tracking of the fault rupture (updates intensity)
3. Your current location tracked by GPS
4. Seconds remaining before seismic waves reach you
5. Expected intensity of quake at your current location
6. Estimated magnitude of quake
7. Intensity scale

A user of the current ShakeAlert user display receives a message like this on the screen of his or her computer. The message alerts the user to how many seconds before the shaking waves arrive at their location and the expected intensity of shaking at that site. The shaking intensity follows the Modified Mercalli scale; an intensity of VI, as shown here, would mean the shaking is felt by everyone, people find it difficult to stand, and structures may suffer some damage. The warning message also displays a map with the location of the epicenter, the magnitude of the quake, and the current position of the P and S waves. In this example, the alert is for the ShakeOut scenario earthquake (Perry and others, 2008).

References

Allen, R., 2013, Seismic hazards; seconds count: Nature, v. 502, no. 7469, accessed 2014 at http://www.nature.com/news/seismic-hazards-seconds-count-1.13838.

Federal Emergency Management Agency, 2008, FEMA 366; HAZUS-MH estimated annualized earthquake losses for the United States: Federal Emergency Management Agency, accessed 2014 at https://www.fema.gov/media-library/assets/documents/13293?id=3265.

Fujinawa, Y., and Noda, Y., 2013, Japan's earthquake early warning system on 11 March 2011—Performance, shortcomings, and changes: Earthquake Spectra, v. 29, no. S1, p. S341–S368, http://dx.doi.org/10.1193/1.4000127.

Given, D.D., Cochran, E.S., Heaton, T., Hauksson, E., Allen, R., Hellweg, P., Vidale, J., and Bodin, P., 2014, Technical implementation plan for the ShakeAlert production system—An earthquake early warning system for the West Coast of the United States: U.S. Geological Survey Open-File Report 2014–1097, 25 p., https://doi.org/10.3133/ofr20141097.

Perry, S., Cox, D., Jones, L., Bernknopf, R., Goltz, J., Hudnut, K., Mileti, D., Ponti, D., Porter, K., Reichle, M., Seligson, H., Shoaf, K., Treiman, J., and Wein, A., 2008, The ShakeOut earthquake scenario—A story that southern Californians are writing: U.S. Geological Survey Circular 1324, 16 p. [Also available at https://pubs.usgs.gov/circ/1324/.]

Wald, D., Wald, L., Worden, B., and Goltz, J., 2003, ShakeMap—A tool for earthquake response: U.S. Geological Survey Fact Sheet 087-03, 4 p., [Also available at https://pubs.usgs.gov/fs/fs-087-03/.]

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Southern California Earthquake Center
Swiss Federal Institute of Technology, Zürich
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