Teacher Guide

Welcome to Teachable Moments! Our goal is to provide timely and accurate information to develop knowledge about a newsworthy earthquake for audiences from middle school through college. Please use the slides to get a concise, but thorough overview of the recent earthquake and then use them as is, or customize it for your students and curriculum.

New for the 2024-25 school year:

1. **Color-coding for grade levels.** ALL middle school + HS high school + C college

1. **Check out the new Slide Guide: Slides or pdf that will guide your students through the slide deck:** middle school pdf high school pdf college pdf
2. **New Geography slide(s): A quick hit about the city or area that gives you cross-curricular connections:** geography, physics, chemistry, biology, environmental science or even history.
3. **NGSS Connections linked to questions in the Slide Guide are located in the notes sections below each slide guide.**
4. **Fill in the blank sub-plans:** The first two pages can be completed and used all year (hint: sheet protector). The rest are for you to modify or fill-in to customize your sub-plans to fit what you're doing.

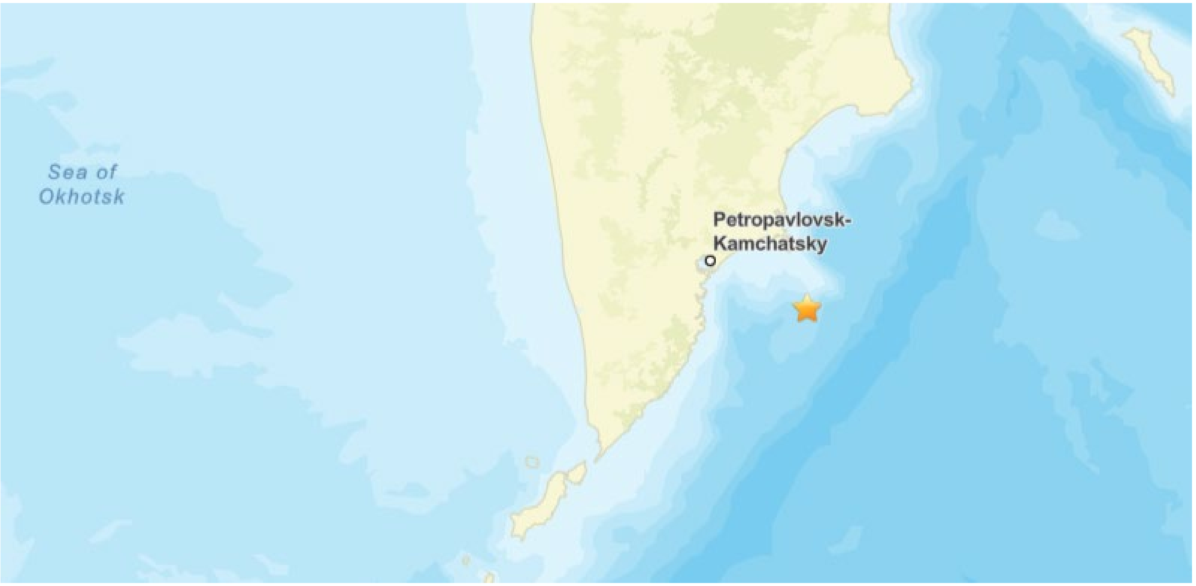
Magnitude 8.8 RUSSIA
Tuesday, July 29, 2025 at 23:24:50 UTC

Latitude 52.512°N
Longitude 160.324°E
Depth 35 km

A powerful magnitude 8.8 earthquake struck off Russia’s Kamchatka Peninsula on July 29, 2025, at a depth of 35 km (21.7 miles), the strongest earthquakes recorded in the region since 1952. *In 1952, this region experienced the world's first recorded magnitude 9 earthquake which triggered a massive tsunami that struck Hawaii, causing over $1 million in damages.*

The July 29, 2025 earthquake triggered tsunami waves up to 5 meters (16 ft) high in Severo-Kurilsk, causing coastal flooding, sweeping away vessels, and damaging infrastructure in the remote Kuril Islands, though no fatalities were reported thanks to effective alerts.

Tsunami warnings and evacuations were issued across the Pacific basin, including Japan, Hawaii, French Polynesia, Chile, Ecuador’s Galápagos Islands, and parts of the US West Coast. Waves up to 1.3 m (4 ft) hit Japan, 1.7 m (5 ft) struck Hawaii, and surges reached 0.5 m (1 ft 7 inches) in California and British Columbia, leading many authorities to downgrade their alerts by evening.



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Tuesday, July 29, 2025 at 23:24:50 UTC

ALL

A drone video posted on X appears to show buildings in the tsunami-hit port town of Severo-Kurilsk submerged in seawater. Authorities said the population of around 2,000 people was evacuated.

Video courtesy of Kamchatka Branch of the Geophysical Survey of the Russian Academy of Sciences

A summary overview of the key features of this M 8.8 earthquake.

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Tuesday, July 29, 2025 at 23:24:50 UTC

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TikTok creator @Outsidenowhere

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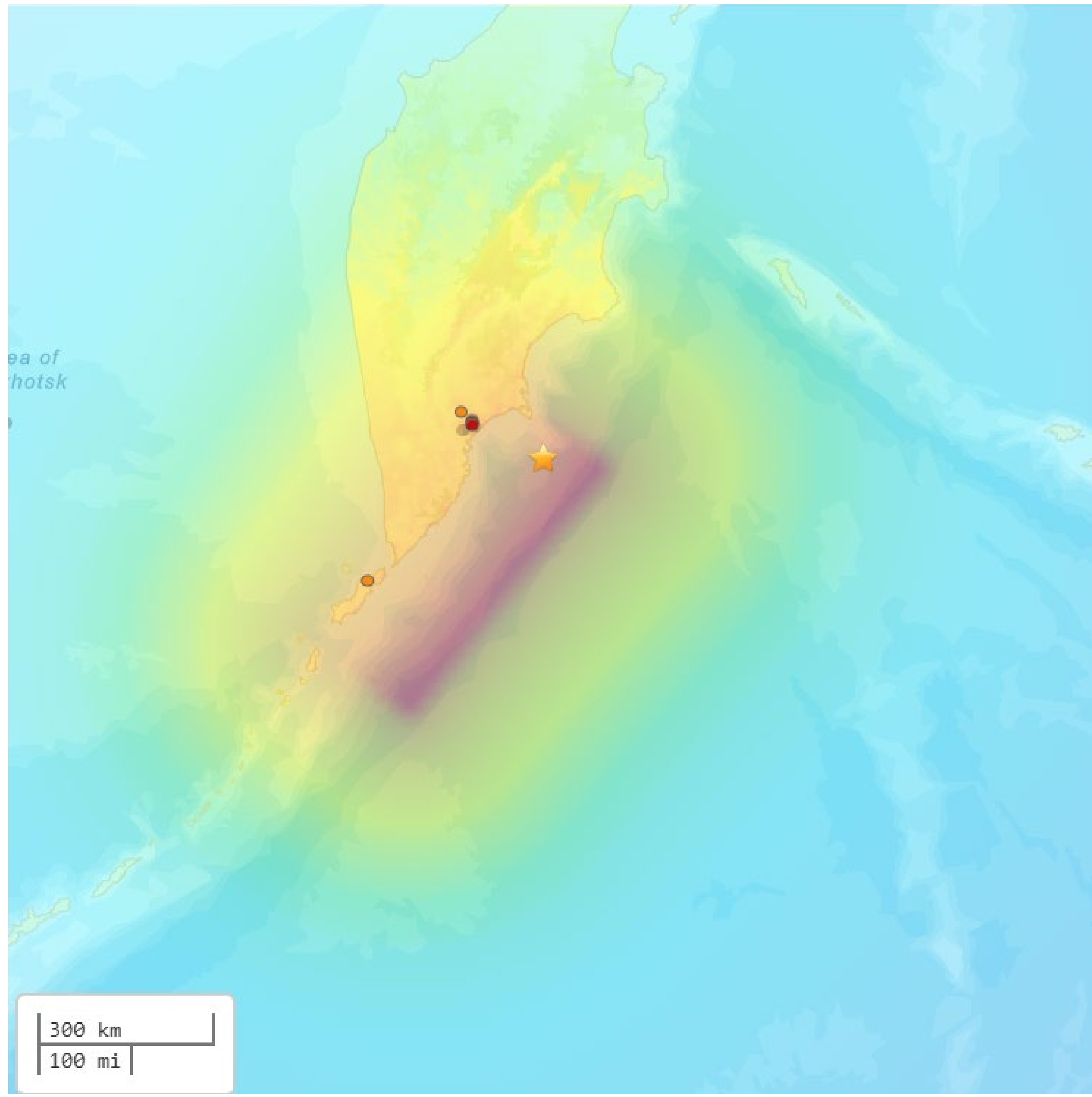
Magnitude 8.8 RUSSIA

Tuesday, July 29, 2025 at 23:24:50 UTC

The Modified-Mercalli Intensity (MMI) scale is a ten-stage scale, from I to X, that indicates the severity of ground shaking.

Intensity is based on observed effects and is variable over the area affected by the earthquake and is dependent on earthquake size, depth, distance, and local conditions.

MMI	Perceived Shaking
X	**Extreme**
IX	**Violent**
VIII	**Severe**
VII	**Very Strong**
VI	**Strong**
V	Moderate
IV	Light
II-III	Weak
I	Not Felt



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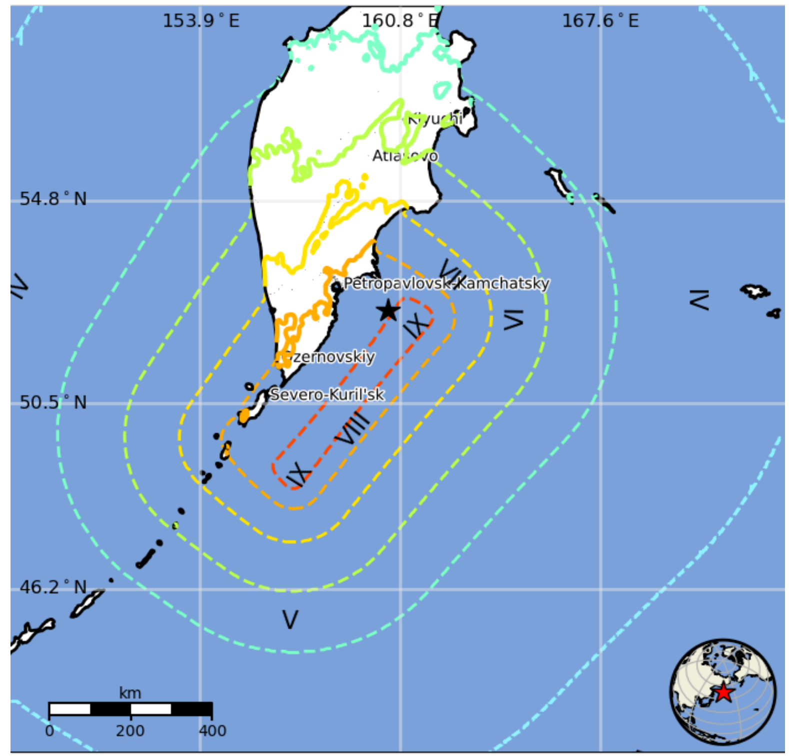
Magnitude 8.8 RUSSIA

Tuesday, July 29, 2025 at 23:24:50 UTC

The USGS PAGER map shows the population exposed to different Modified Mercalli Intensity (MMI) levels. The USGS estimates that approximately 257,000 people felt severe shaking from this earthquake.

MMI	Shaking	Population
I	Not Felt	0 k*
II-III	Weak	0 k*
IV	Light	6 k*
V	Moderate	16 k
VI	Strong	8 k
VII	Very Strong	17 k
VIII	Severe	257 k
IX	Violent	0 k
X	Extreme	0 k

*Estimated exposure only includes population within map area (k = x1,000)



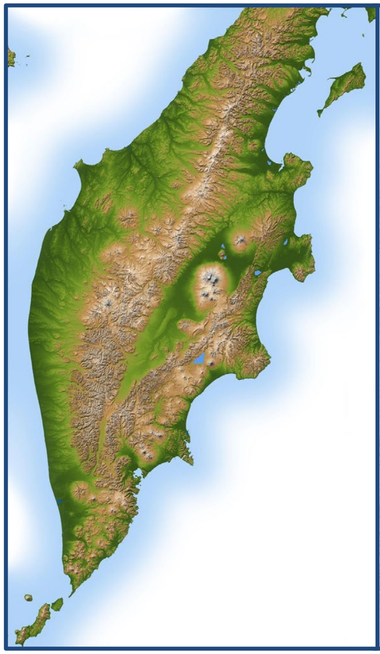
The color-coded contour lines outline regions of MMI intensity. The total population exposure to a given MMI value is obtained by summing the population between contour lines. The estimated population exposure to each MMI Intensity is shown in the table.

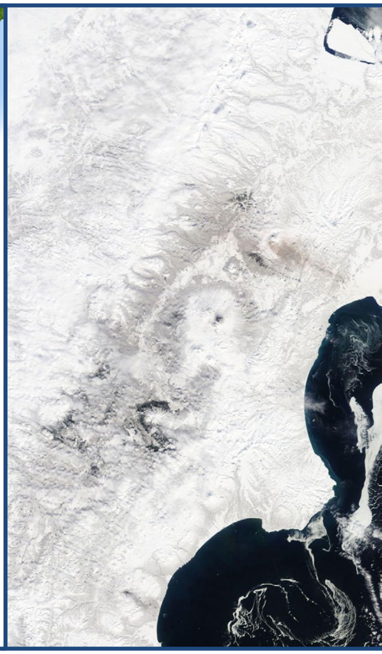
Image courtesy of the US Geological Survey

Magnitude 8.8 RUSSIA
Tuesday, July 29, 2025 at 23:24:50 UTC

ALL

The Kamchatka Peninsula is dubbed the "land of fire and ice." There are approximately 160 volcanoes in volcanic ranges with 29 active volcanoes around the central valley of the Kamchatka River and 19 active volcanoes on the Peninsula with the Klyuchevskaya Sopka Volcano being the highest volcano at 15580 ft. (4750m). To go with all of the volcanoes, it is covered with ice from October to May and has glaciers in the northern regions.





It has a diverse topography and geography with rivers, lakes and ocean resources. Its capital is Petropavlovsk-Kamchatsky. The economy is based on fishing, timber, gold, coal, and shipbuilding as well as tourism where skiing and the thermal and mineral springs are a few of the attractions.

Magnitude 8.8 RUSSIA

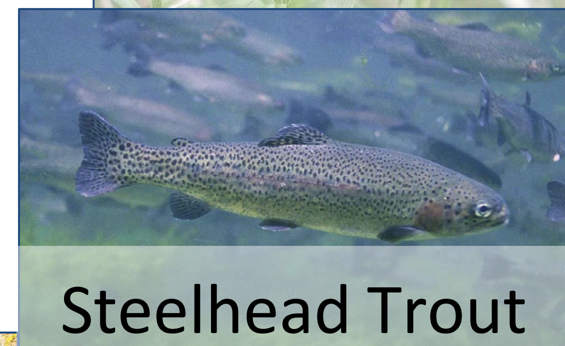
Tuesday, July 29, 2025 at 23:24:50 UTC

ALL

Because of the varied terrain and climate, and the minimal amount of human development, the Kamchatka Peninsula has a high degree of biodiversity. Animals and plants need to be adapted to subarctic, ice cap, polar, subpolar, and oceanic climates, among others.

There are 5 nature reserves, but many endangered species due to loss of habitat, hunting, and overfishing; the Kamchatka Brown Bear, Steelhead trout, and Steller's Sea Lion are among those threatened.


Kamchatka


Steelhead Trout


Kamchatka Brown Bear


Forest tundra


Stellar's Sea Lion

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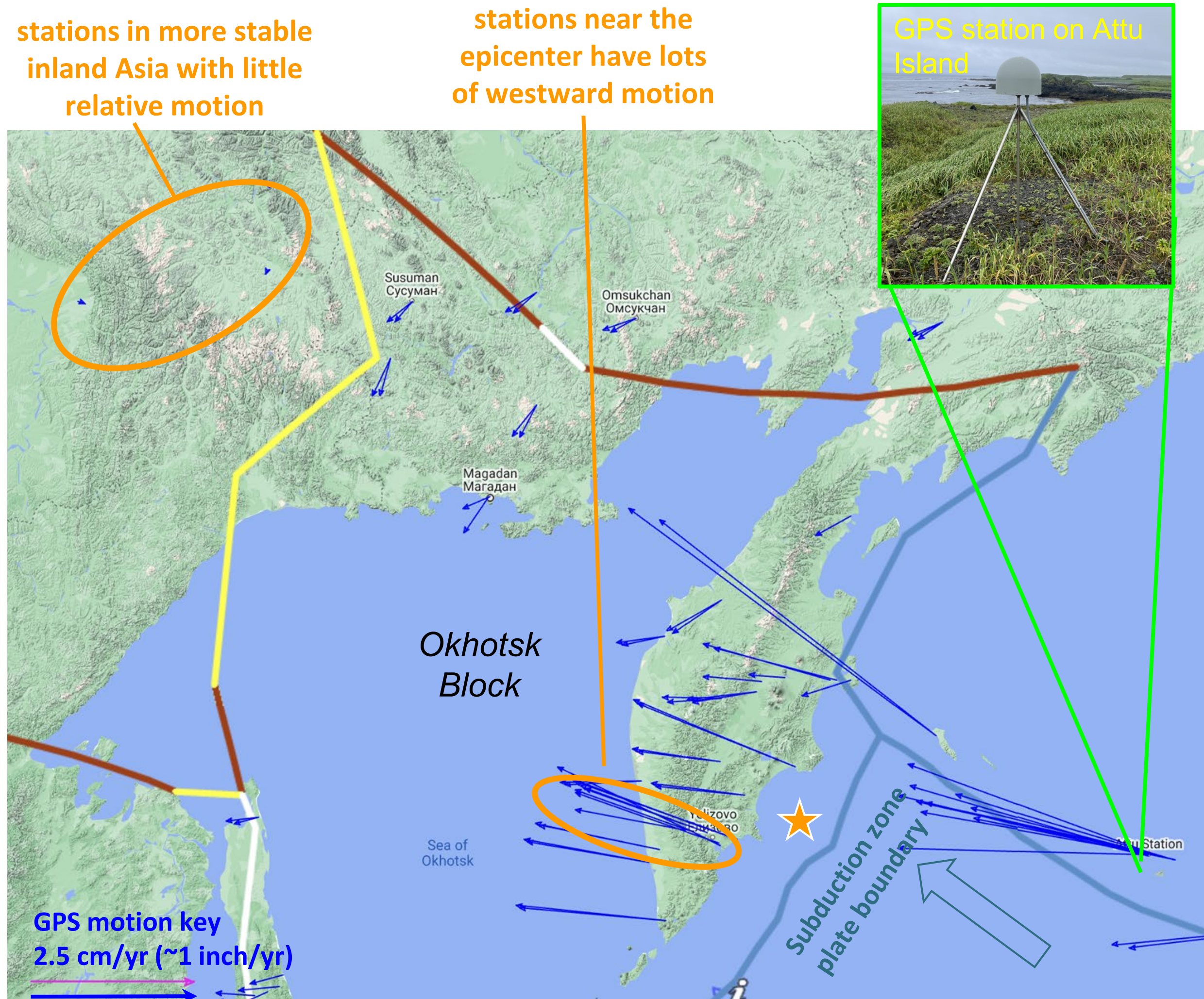
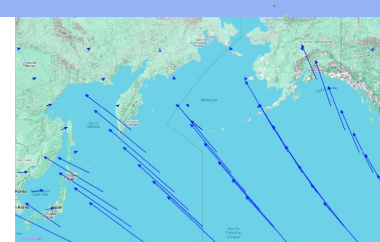
Tuesday, July 29, 2025 at 23:24:50 UTC

Russia and neighboring countries have GPS stations that record the long-term motion from plate tectonics (Attu Island is part of Alaska, USA).

Compared to stations in more stable inland Asia, stations near Kamchatsky are moving as much as 2.5 cm/yr (~1 inch/yr) towards the west as the Pacific Plate pushes against the Okhotsk Block.

Over decades and centuries this compression accumulates and is occasionally released in earthquakes such as the magnitude 8.8 quake on July 29, 2025.





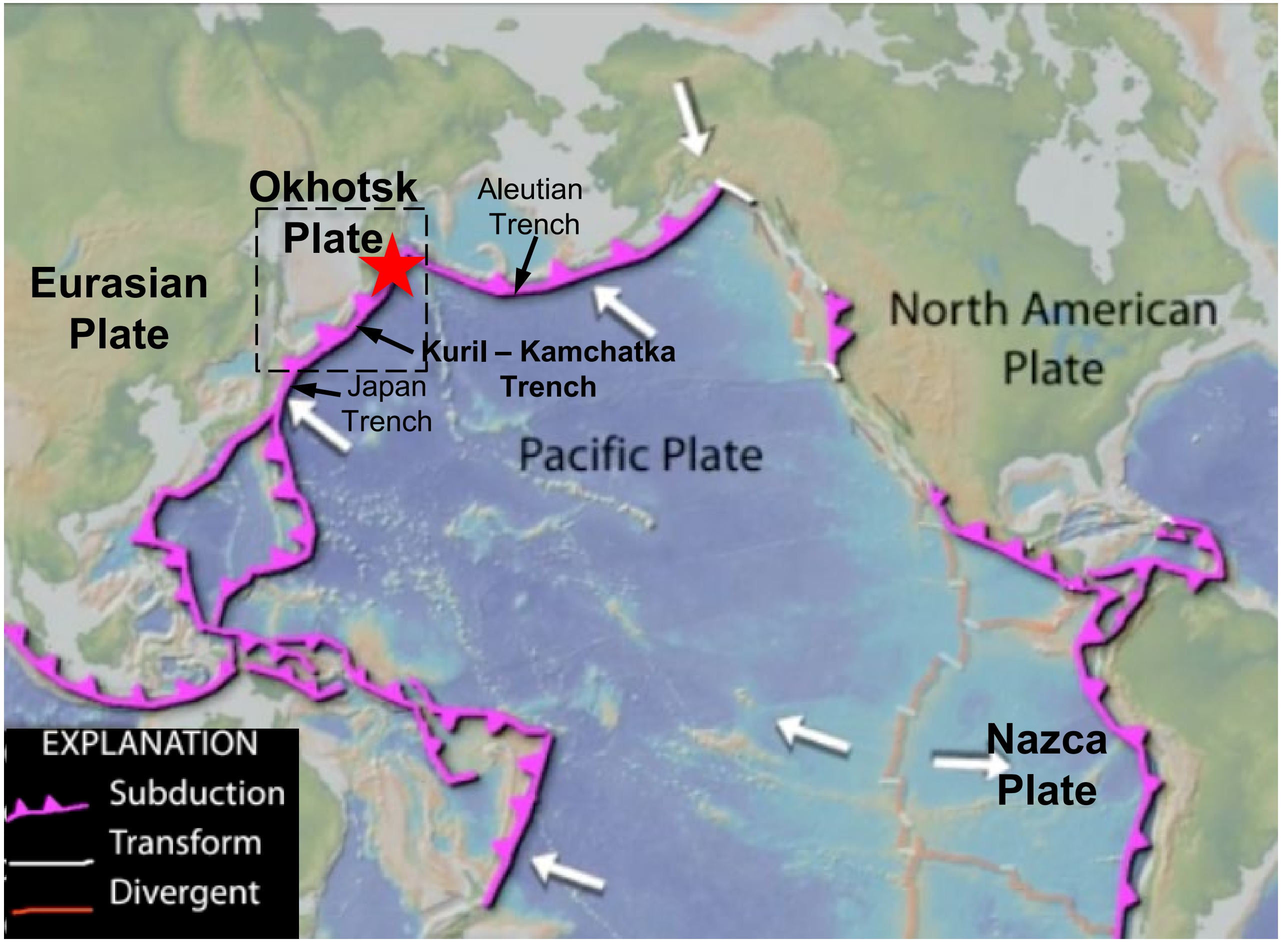
Pacific basin view of plate motions

Magnitude 8.8 RUSSIA

Tuesday, July 29, 2025 at 23:24:50 UTC

The epicenter of the July 29, 2025 magnitude 8.8 earthquake off the east coast of the Kamchatka Peninsula is shown by the red star on this map. This earthquake occurred on the plate boundary between the subducting Pacific Plate and the overriding Okhotsk Plate.

At the Kuril-Kamchatka Trench near this great earthquake, the Pacific Plate subducts at a rate of 77 mm/yr (7.7 cm/yr).



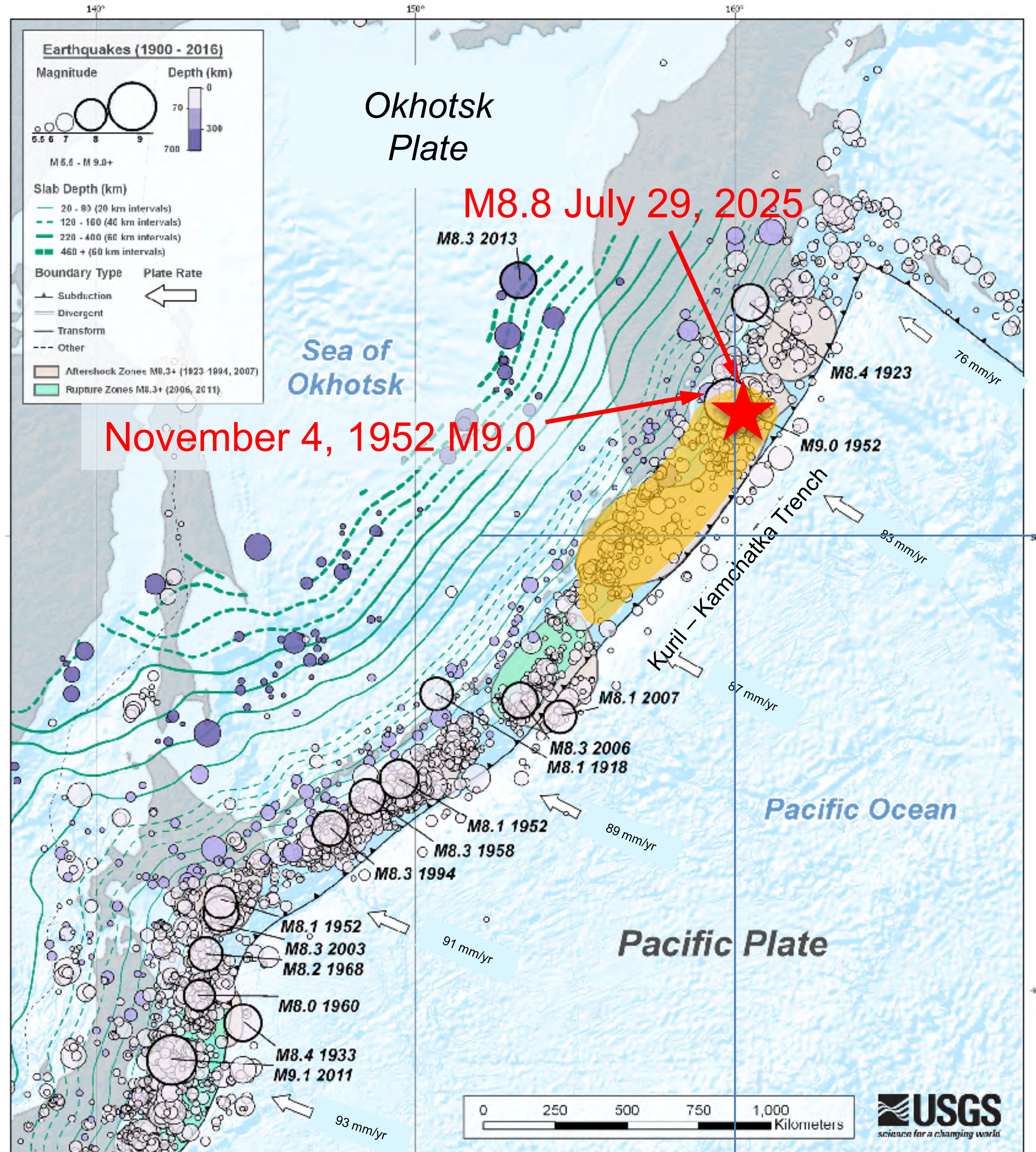
A detailed map of the area within the dashed outline is presented on the next slide.

Magnitude 8.8 RUSSIA

Tuesday, July 29, 2025 at 23:24:50 UTC

The red star on this map shows the epicenter of the July 29, 2025 magnitude 8.8 earthquake while the orange shading shows the rupture zone. Location, depth, and thrust-fault focal mechanism of this earthquake indicate that it occurred on the plate boundary megathrust between the Okhotsk and Pacific plates.

From 1900 to present, the Kuril – Kamchatka subduction zone has produced 13 great (M≥8.0) earthquakes. The largest of these was the November 4, 1952 magnitude 9.0 earthquake, the 5th largest instrumentally recorded earthquake in history. At magnitude 8.8, the July 29, 2025 earthquake is the second largest on this subduction zone since 1900 and is one of the ten largest instrumentally recorded earthquakes.



Map courtesy of US Geological Survey

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Tuesday, July 29, 2025 at 23:24:50 UTC

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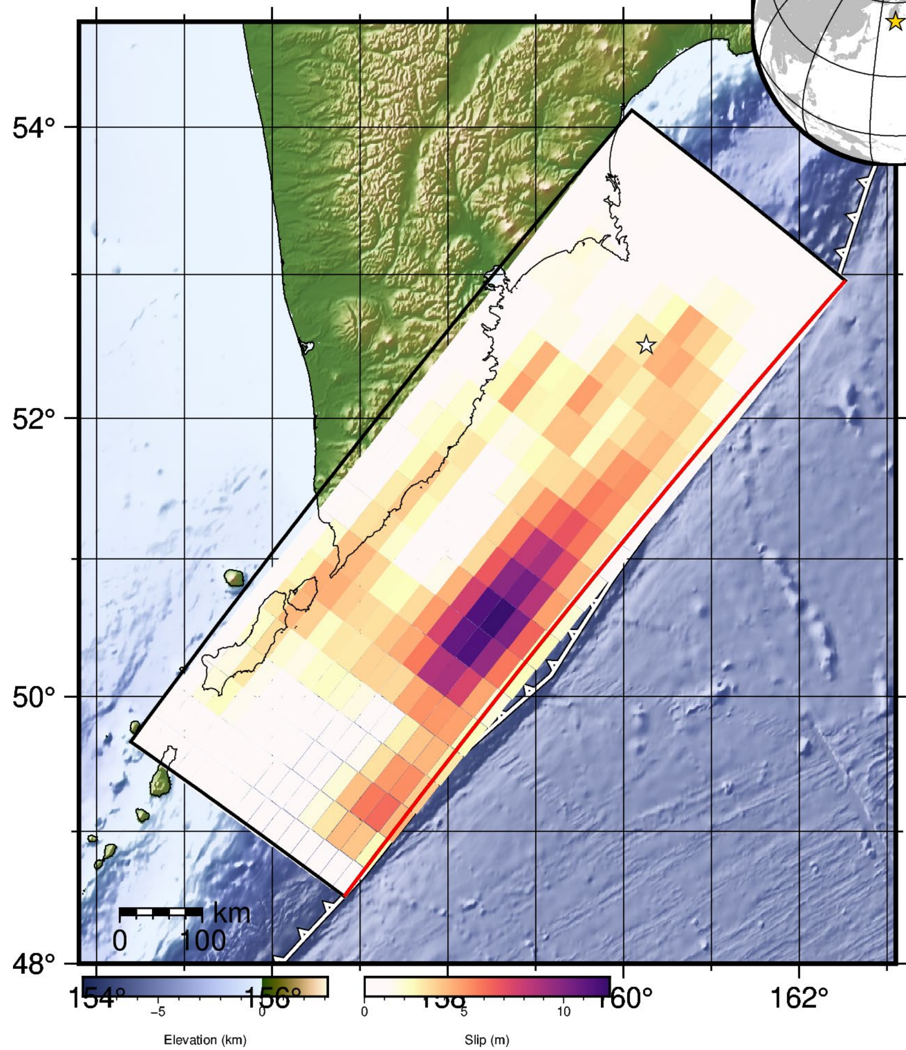
Superimposing the slip distribution on a map allows visualization of the size of the rupture from this earthquake.

The slip wasn't uniform across the fault. After an earthquake, the stress on the fault changes. Aftershocks occur due to these stress changes and they often occur on or near the main fault.



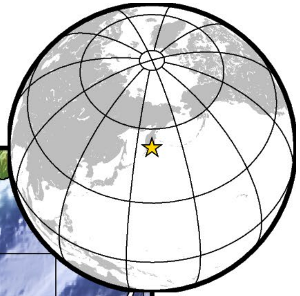


Image courtesy of the U.S. Geological Survey

Magnitude 8.8 RUSSIA
Tuesday, July 29, 2025 at 23:24:50 UTC

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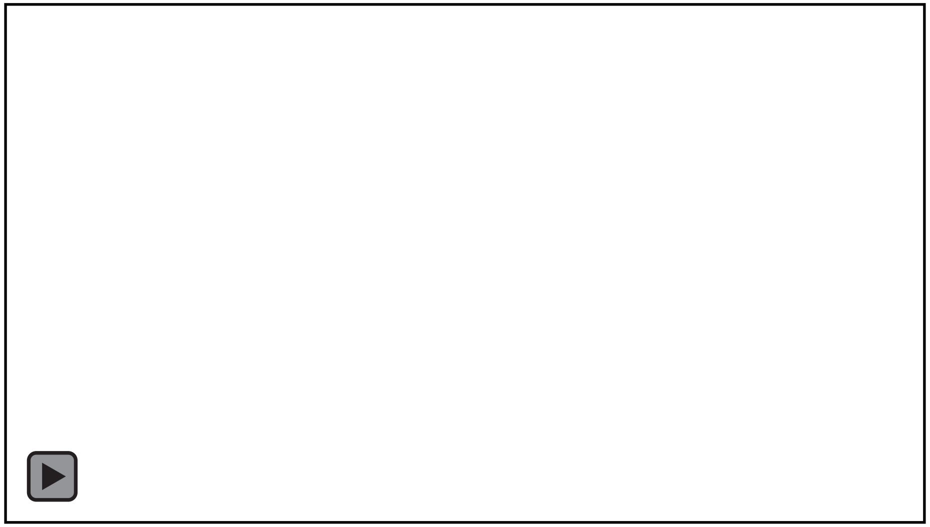
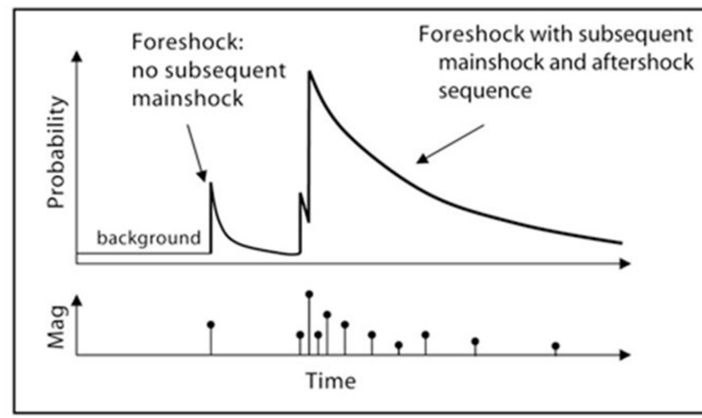


A **foreshock** is a smaller magnitude earthquake that precedes the mainshock. There are no special characteristics of a foreshock that let us know it is a foreshock until the mainshock occurs.

A **mainshock** is largest magnitude earthquake during an earthquake sequence.

Aftershocks are smaller earthquakes occurring after a large earthquake as the fault adjusts to the new state of stress.



The graph shows how the number of aftershocks and the magnitude of aftershocks decay with increasing time since the main shock. The number of aftershocks also decreases with distance from the main shock.

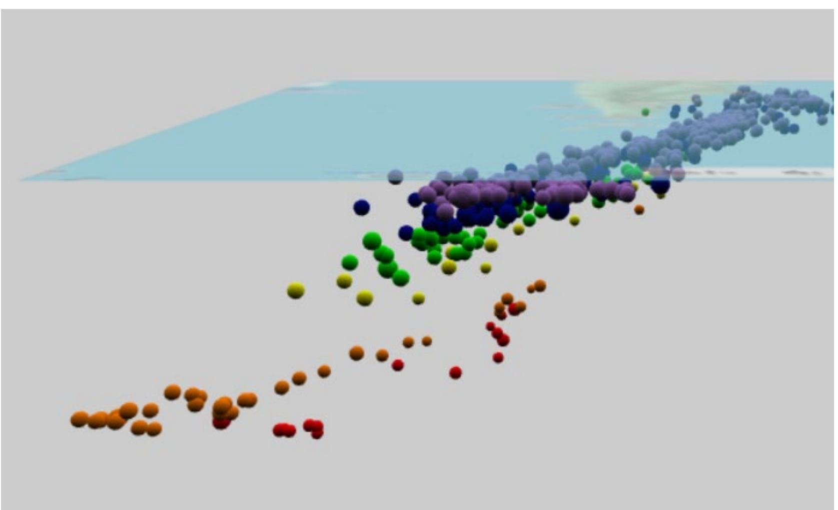
ALL

Magnitude 8.8 RUSSIA

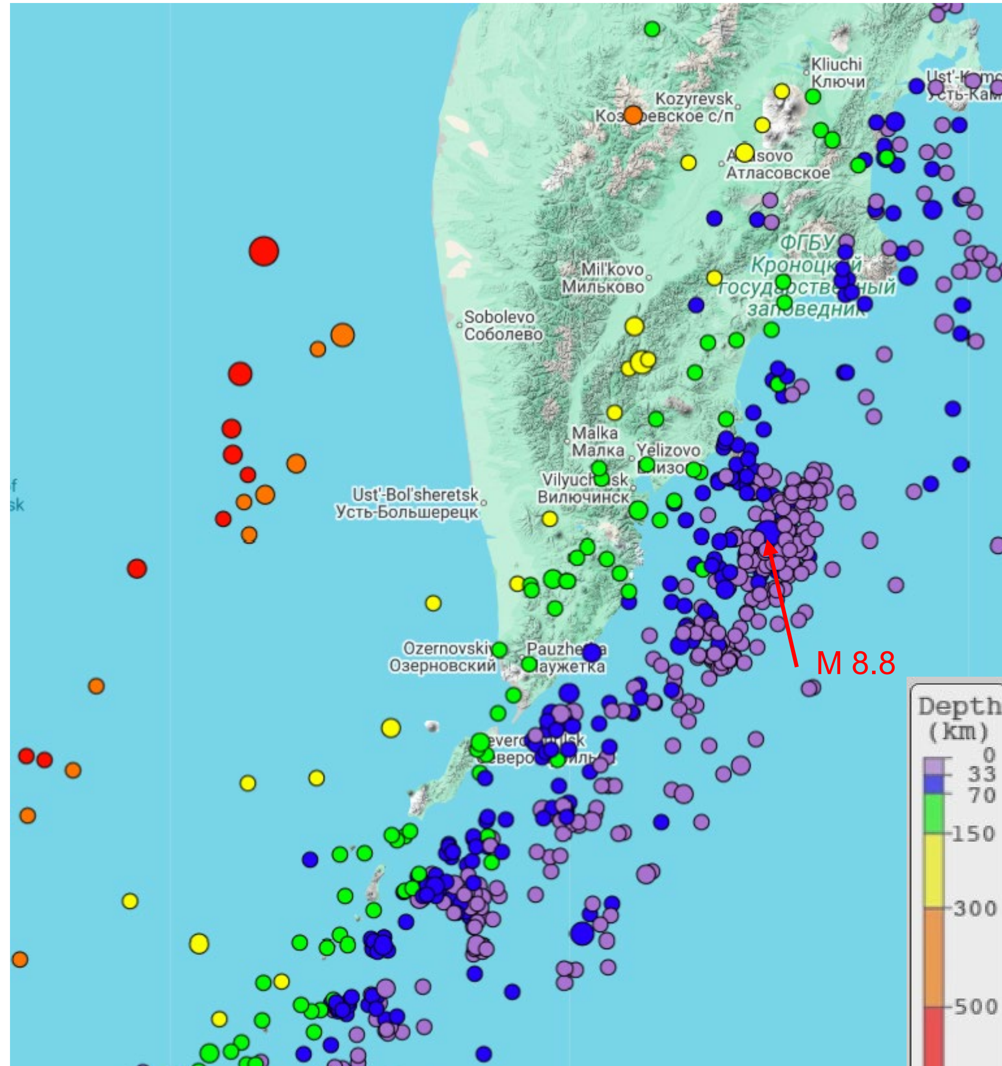
Tuesday, July 29, 2025 at 23:24:50 UTC

The map on the right shows historic earthquake activity > M 5 near the epicenter (star) from 1990 to present.

Below is a 3D view of this region, earthquakes are shallow (purple) at the trench and increase in depth towards the west as the Pacific Plate dives beneath the Okhotsk Plate.



Seismicity Cross Section showing earthquakes highlighting the megathrust plate boundary



Images created with the Interactive Earthquake Browser

ALL

Magnitude 8.8 RUSSIA

Tuesday, July 29, 2025 at 23:24:50 UTC

Exploring tectonic setting, 5 years of seismicity, and foreshocks and aftershocks of this M 8.8 earthquake.

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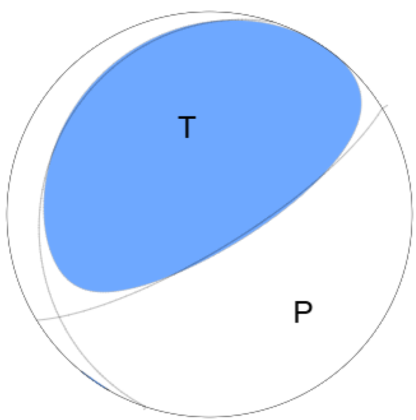
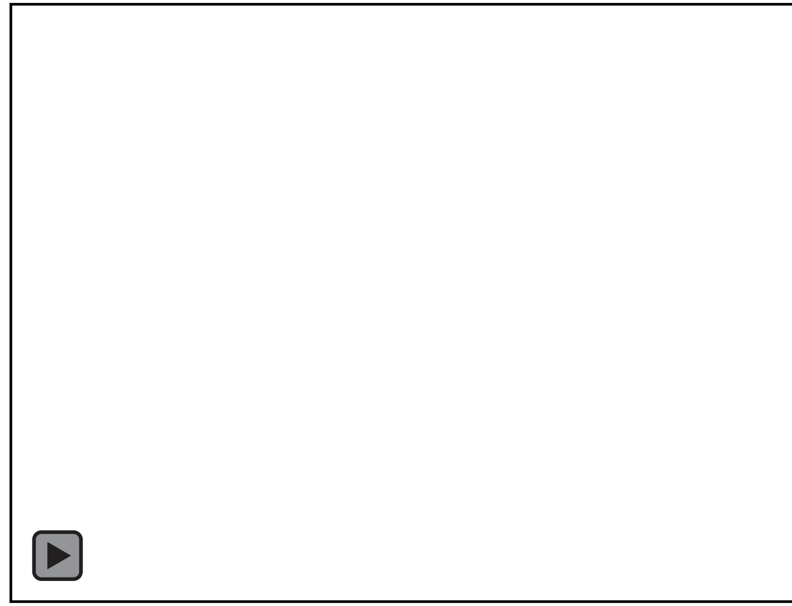
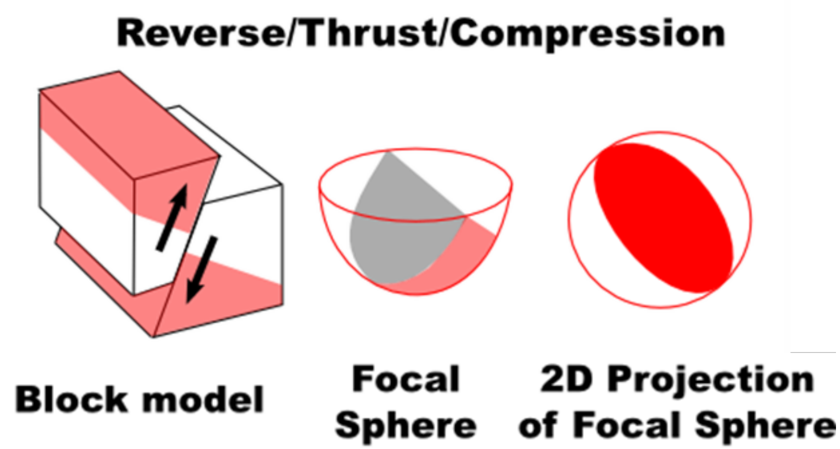
The focal mechanism is how seismologists plot the 3-D stress orientations of an earthquake. Because an earthquake occurs as slip on a fault, it generates primary (P) waves in quadrants where the first pulse is compressional (shaded) and quadrants where the first pulse is extensional (white). The orientation of these quadrants determined from recorded seismic waves determines the type of fault that produced the earthquake.



USGS W-phase Moment Tensor Solution

The tension axis (T) reflects the minimum compressive stres direction. The Pressure axis (P) reflects the maximum compressive stress direction.





ALL

Magnitude 8.8 RUSSIA

Tuesday, July 29, 2025 at 23:24:50 UTC

An animation exploring tsunami generation at subduction zones.

Magnitude 8.8 RUSSIA

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- **What is a tsunami?** It is a series of swift, powerful floods of water, not a single, enormous wave. More waves can follow anywhere from 5–90 minutes (or for hours) after the initial wave, sometimes lasting 24–48 hours after the initial wave.
- The powerful subduction earthquake off the coast of the Kamchatka Peninsula dramatically uplifted the ocean floor in a matter of moments generating a tsunami that propagated across the Pacific Basin.

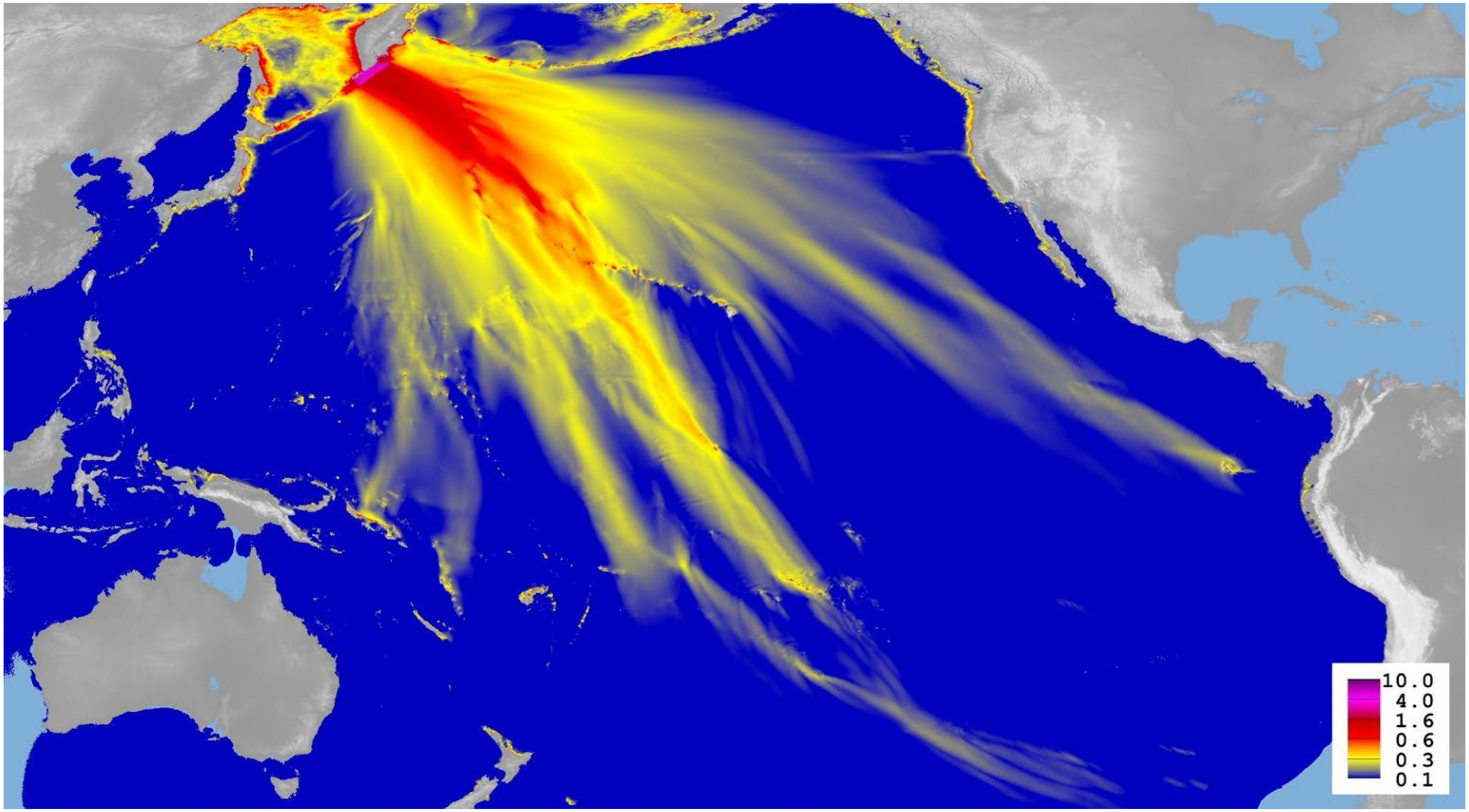
Magnitude 8.8 RUSSIA

Tuesday, July 29, 2025 at 23:24:50 UTC

ALL

Modeled tsunami wave height (in meters)

Source: GFZ



wave height (meters)

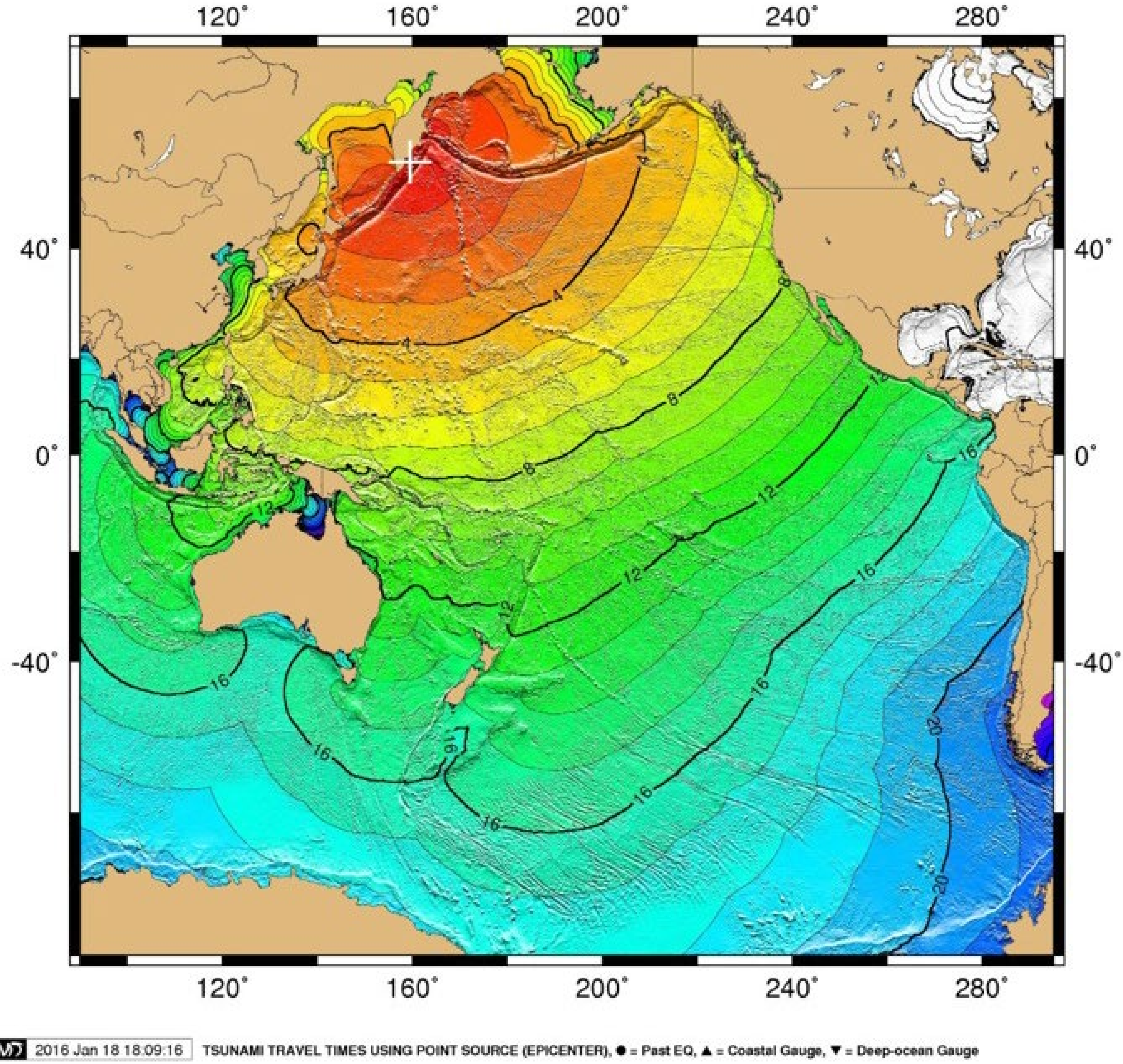
"It might only be 3 feet, but it's a wall of water that's 3 feet and spans hundreds of miles. Three feet of water can easily inundate inland and flood a couple blocks inland from the beach,"

Diego Melgar, director Cascadia Region Earthquake Science Center @ University of Oregon

Magnitude 8.8 RUSSIA

Tuesday, July 29, 2025 at 23:24:50 UTC

Estimated Tsunami Travel Time Map (Hours)



Source:
International Tsunami Center

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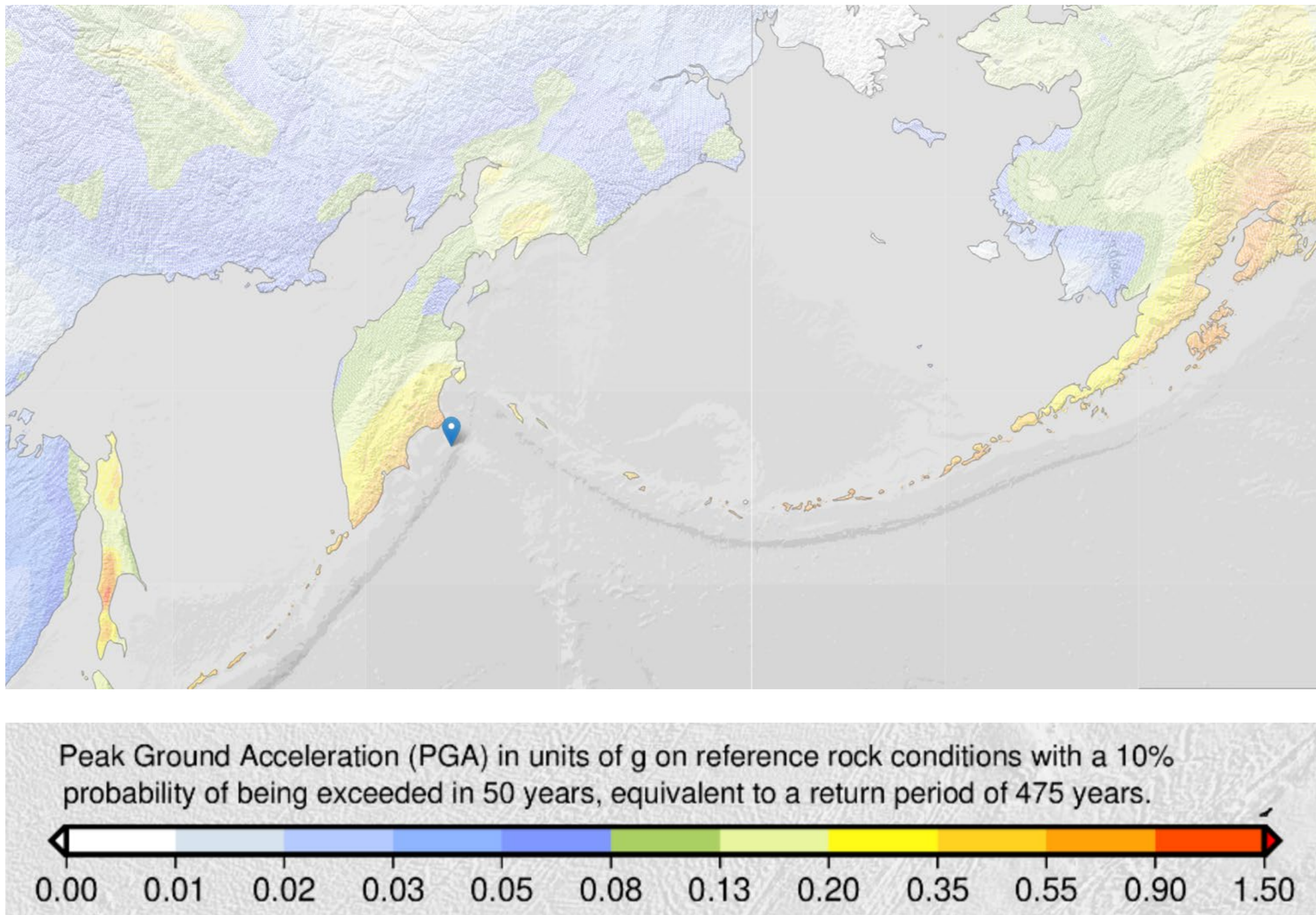
Magnitude 8.8 RUSSIA
Tuesday, July 29, 2025 at 23:24:50 UTC

- **Seismic hazard** is the likelihood and severity of potentially damaging earthquakes at a location.
- PGA values are depicted on seismic hazard maps to illustrate expected ground shaking levels across different regions, aiding in planning and construction standards.
- Measurement Units: PGA is commonly expressed as a fraction or percentage of Earth's gravitational acceleration ($g = 9.81\ m/s^2$).
- While PGA indicates the severity of ground motion at a site, it doesn't directly measure the total energy released by an earthquake, which is represented by magnitude scales.



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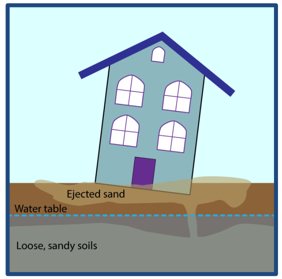


Liquefaction Hazard

Earthquake shaking can cause saturated soil to lose strength, resulting in the soil behaving more like a liquid than a solid.

The liquefaction estimate is calculated by considering the peak ground acceleration, the soil susceptibility and the depth to water table.

Liquefaction Probability

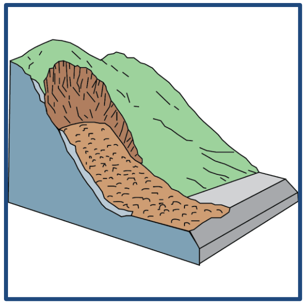
< 0.5%	0.5-1%	1-2%	2-5%	5-10%	10-20%	> 20%

Epicenter ★

Magnitude 8.8 RUSSIA

Tuesday, July 29, 2025 at 23:24:50 UTC

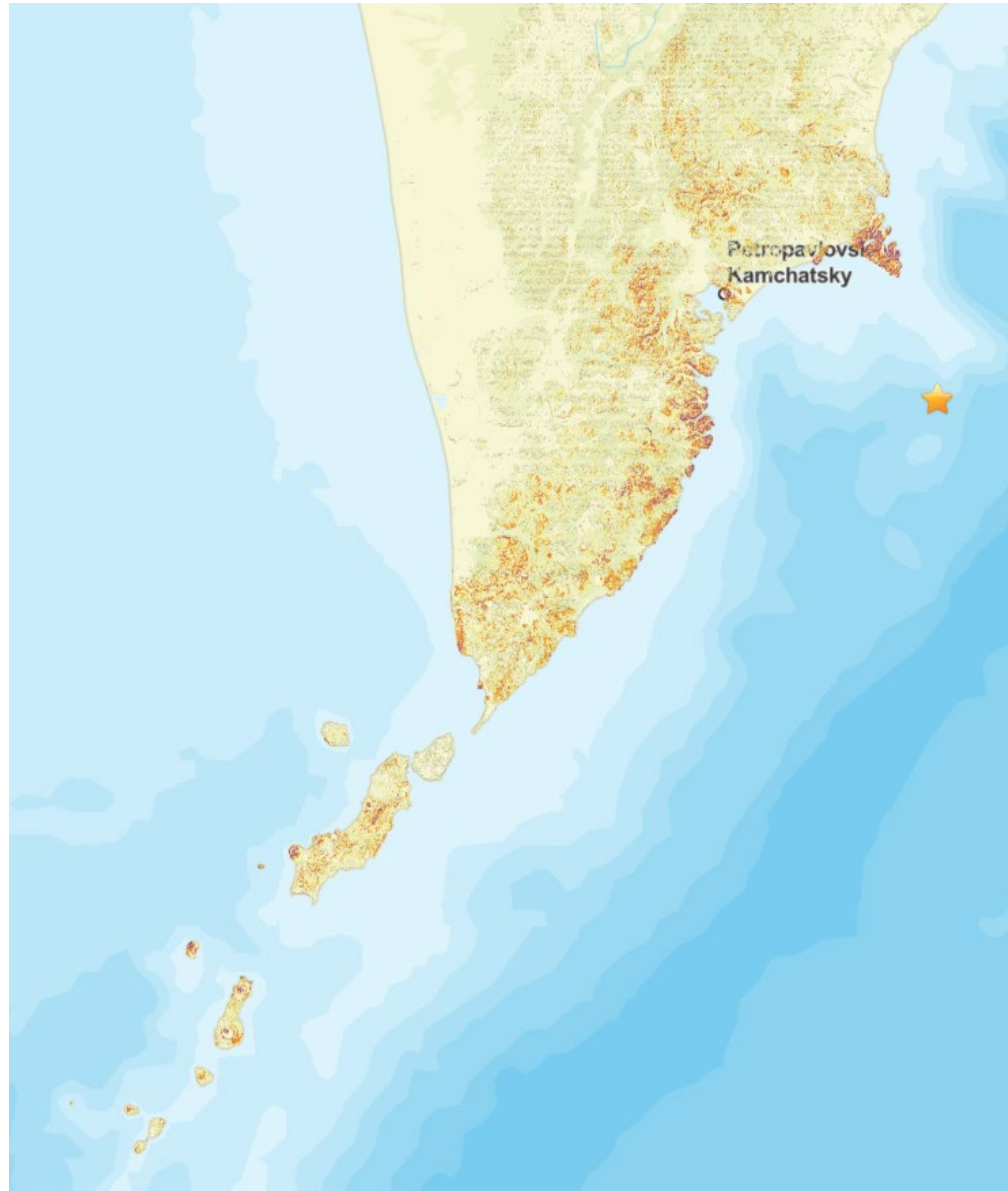
ALL



Landslide Hazard

Earthquakes can trigger landslides over wide areas causing societal disruptions by blocking roads, destroying infrastructure, and damming waterways causing flooding hazards. Landslides can happen during aftershocks and heavy precipitation events.

The landslide probability is estimated by considering ground shaking intensity, topographic slopes, and soil or geological conditions.



Landslide Probability

< 0.2%	0.2-1%	1-2%	2-5%	5-10%	10-20%	> 20%

Epicenter ★

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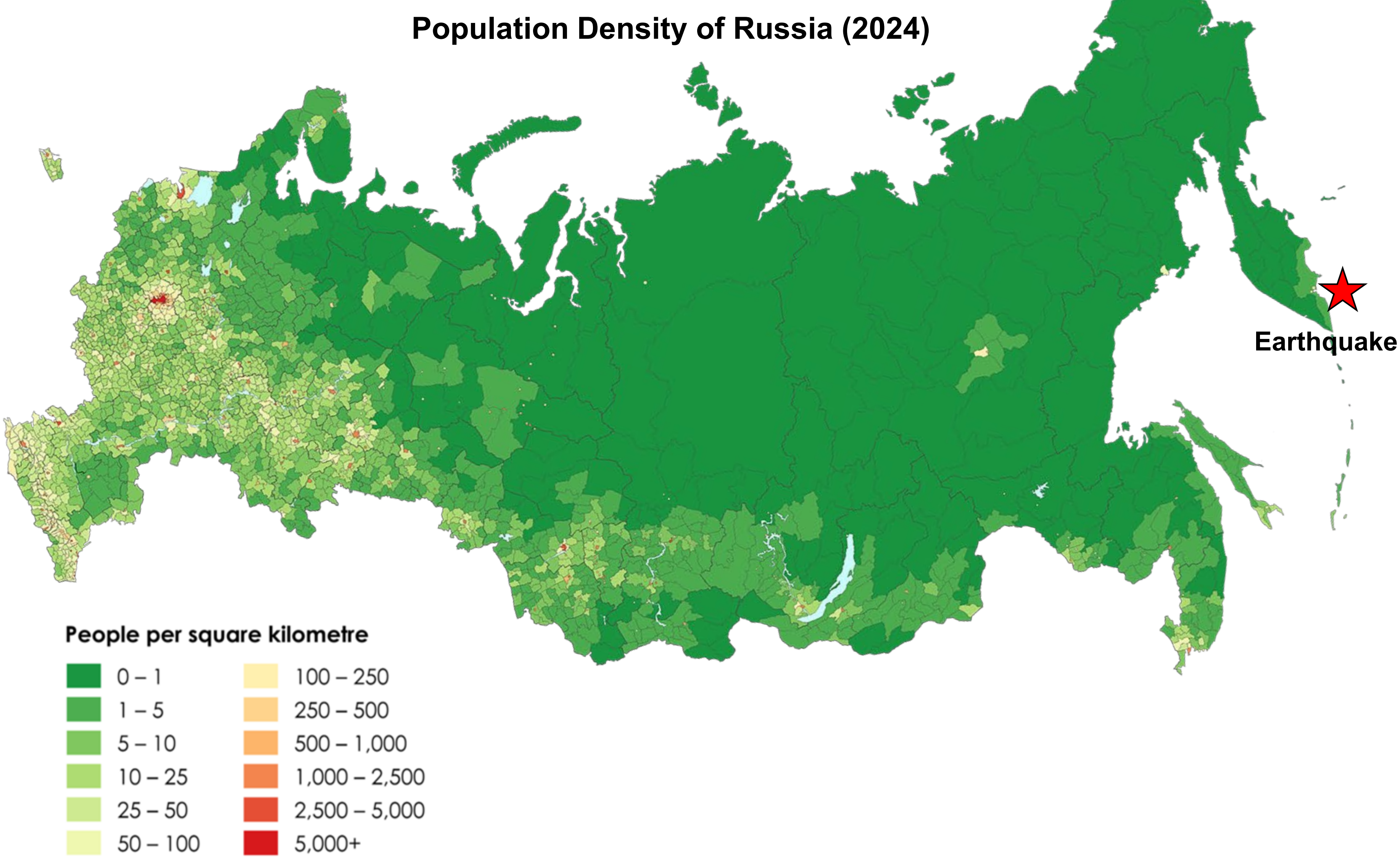
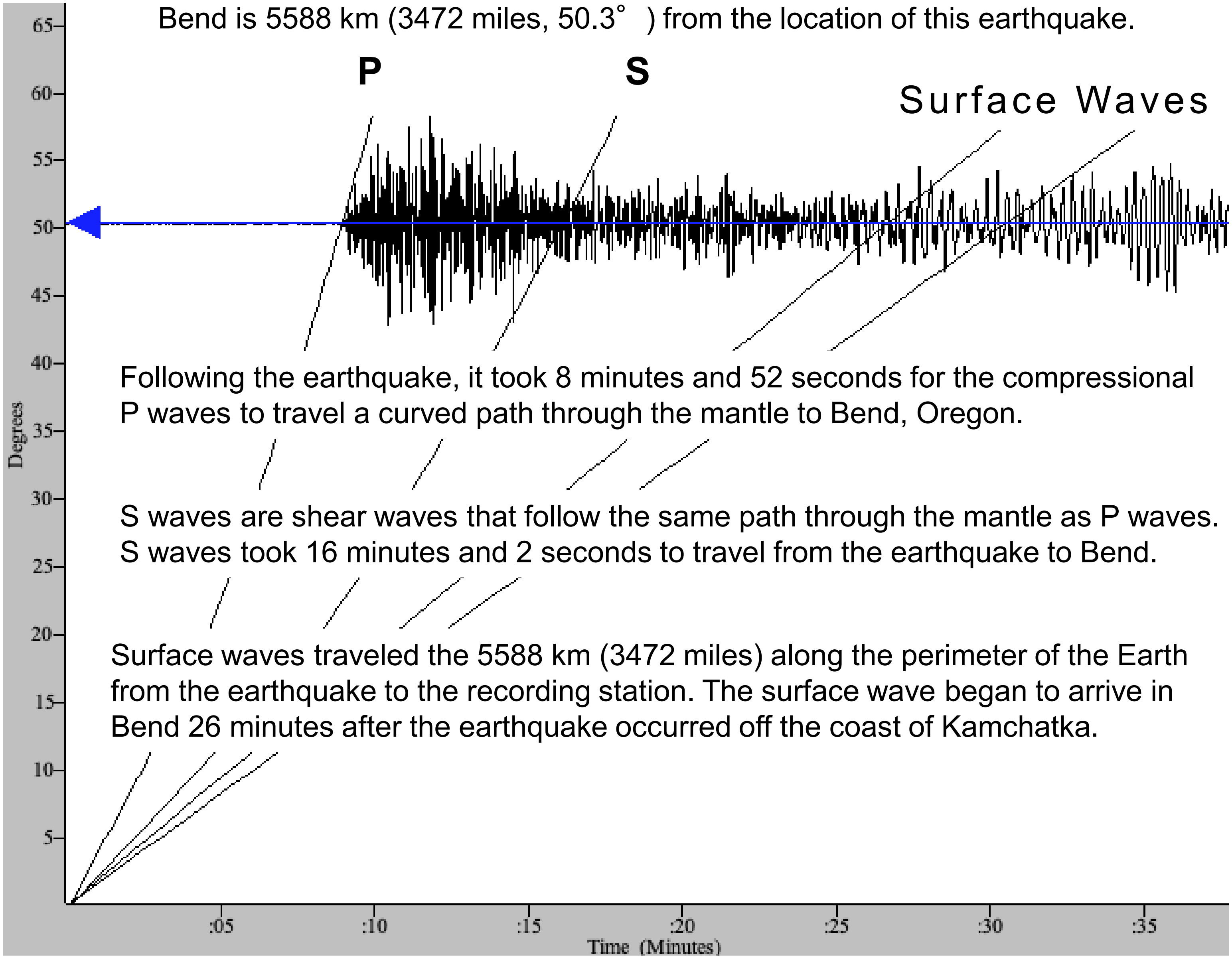


Magnitude 8.8 RUSSIA
Tuesday, July 29, 2025 at 23:24:50 UTC

ALL

The record of the earthquake in Bend, Oregon (BNOR) is illustrated below.
Bend is 5588 km (3472 miles, 50.3°) from the location of this earthquake.



Following the earthquake, it took 8 minutes and 52 seconds for the compressional P waves to travel a curved path through the mantle to Bend, Oregon.

S waves are shear waves that follow the same path through the mantle as P waves. S waves took 16 minutes and 2 seconds to travel from the earthquake to Bend.

Surface waves traveled the 5588 km (3472 miles) along the perimeter of the Earth from the earthquake to the recording station. The surface wave began to arrive in Bend 26 minutes after the earthquake occurred off the coast of Kamchatka.

Slide Guide

ALL

1. Where was the epicenter of this earthquake? (What city/region was it closest to?) When did the earthquake happen? What was its magnitude?
2. How many people are estimated to have felt the earthquake?
3. Which type of boundary is this earthquake related to?
4. What impact did the earthquake have on the location in which it was felt the strongest? (buildings, streets, animals, people…)
5. What additional hazards occurred in addition to the ground shaking? (tsunamis, floods, sinkholes, landslides, fires, volcanoes…)
6. How long did it take the first P-wave to travel to the seismic station in this slide stack?
7. What are 2 more questions you have about earthquakes that can NOT be answered with this slide stack?

Extension Questions

1. Seismic waves travel through the earth. Why did you or did you not feel the earthquake?
2. If you were going to write a news story on this earthquake, what would the headline be? *HINT: Think about where this earthquake occurred, the impact it had on the people living in the area, any effects the earthquake had on the area itself.*

HS

Slide Guide

1. Where was the epicenter of this earthquake? (What city/region was it closest to?) When did the earthquake happen? What was its magnitude?
2. How many people are estimated to have felt the earthquake?
3. What relationship is shown between the seismic hazard map and population density?
4. Which plates are involved and what type of boundary are they creating?
5. What impact did the earthquake have on the location in which it was felt the strongest? (buildings, streets, animals, people…)
6. What additional hazards occurred in addition to the ground shaking? (tsunamis, floods, sinkholes, landslides, fires, volcanoes…)
7. How long did it take the first P-wave to travel to the seismic station in this slide stack?
8. What are 2 more questions you have about earthquakes that can NOT be answered with this slide stack?

Extension Questions

1. Seismic waves travel through the earth. Why did you or did you not feel the earthquake?
2. If you were going to write a news story on this earthquake, what would the headline be? *HINT: Think about where this earthquake occurred, the impact it had on the people living in the area, any effects the earthquake had on the area itself.*

C

Slide Guide

1. Where was the epicenter and hypocenter of this earthquake? (What city/region was it closest to? Longitude/latitude/depth?) When did the earthquake happen? What was its magnitude?
2. What impact did the earthquake have on the location in which it was felt the strongest? *(buildings, streets, animals, people…)*
3. Draw the block model of the fault for this earthquake. Overlay a drawing of the focal mechanism to show how the 2D projection was created. Label it with the type of fault.
4. How are the related tectonic plates involved in creating the nearby boundary? *(Include the type of boundary, and the velocity and name of the plates.)*
5. What additional hazards occurred in addition to the ground shaking? *(tsunamis, floods, sinkholes, landslides, fires, volcanoes…)*
6. Relate the area's population density to its seismic hazard level and earthquake history.

Extension Question

1. What efforts have there been to mitigate impacts from earthquakes? What additional mitigation efforts should be implemented?

Teachable Moments are a service of

The EarthScope Consortium

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