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Not My Fault: The Global Quake Story of 2025

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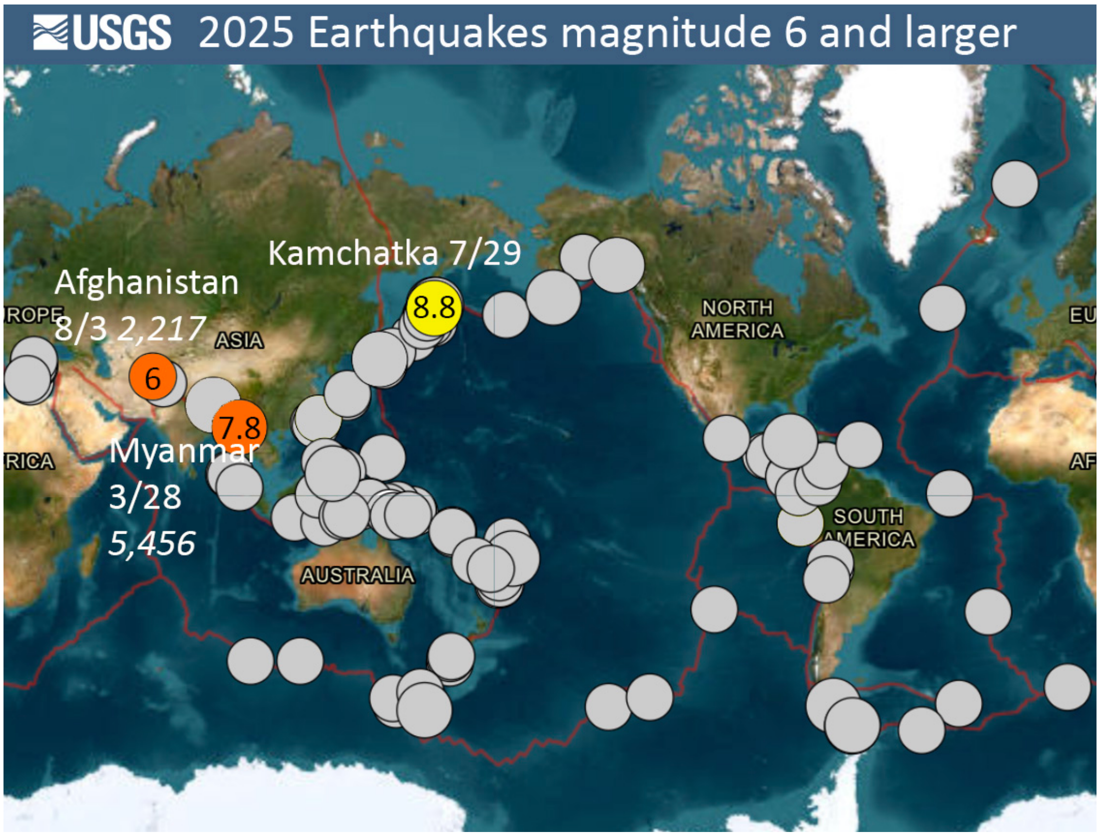

This map shows the 145 earthquakes registered by the USGS with magnitudes of 6 and larger in 2025. The largest earthquake of the year was off the coast of Russia's Kamchatka peninsula (yellow). The two deadliest earthquakes (orange) were in Asia: a 7.8 in Myanmar and a 6.0 in Afghanistan.

2025 featured a giant earthquake that caused little damage and two smaller ones that were much more deadly. More seismic energy was released in 2025 than at any time in the last 14 years, but the global death toll was well below the average annual casualty numbers of the past half century. Most of the earthquakes were in the usual places but there were a few surprises. Here's a short recap of the shaky moments of 2025.

The biggest quake of the year was enormous. The July 29th M8.8 Kamchatka earthquake is the largest earthquake anywhere on the planet since the M9.1 Great East Japan earthquake of 2011. It released 32 times more energy than the second-place contender, the March 28th M7.8 Myanmar earthquake. The "kick' generated when 370 miles of the Kuril-Kamchatka subduction zone ruptured caused the entire planet to vibrate for nearly a week. We call these oscillations normal modes, and they are akin to the ringing of a bell when struck. They are far too slow for people to notice, but the periods and strength of these vibrations help constrain internal earth structure.

What has been learned in the almost six months since the earthquake? The most interesting news has been about the tsunami. It's nearly impossible to get a detailed picture of a tsunami as it travels across an ocean. The DART pressure sensors on the sea floor give a picture of the oscillations at distinct spots in the ocean. The Kamchatka tsunami was large enough to trigger eight instruments in the Pacific, four in the NW Pacific and three scattered from the Marshall Islands to the Tonga Islands. These instruments are great at providing a time series of the tsunami as it passes over that location and are important tools for forecasting the likely tsunami height at coastal locations. But they say nothing about the complexity of the tsunami characteristics away from those few points.

Fortuitously, the NASA SWOT (Surface Water and Ocean Topography) satellite was traversing an arc roughly 100 miles off the Kamchatka Peninsula 70 minutes after the earthquake, just as the tsunami was travelling beneath it. This wasn't the first time a satellite was in the right place to detect a tsunami. In the 2004 Indian Ocean tsunami the US/French Jason satellite captured the changes in sea level surface height during the Indian ocean tsunami, but Jason was not nearly as sophisticated as SWOT.

The SWOT satellite mission, also a joint US/French collaboration, was launched in 2022 with the specific goal of continuously monitoring the earth's surface water. The radar instrumentation allows it to measure not only water levels to a much higher degree of precision than Jason, but also current speeds. SWOT's orbital path allows it to cover 90% of the earth's surface over a 21-day period. Good luck indeed that placed it in exactly the right spot to see the Kamchatka tsunami unfold.

SWOT revealed both details and surprises to tsunami scientists. Unlike Jason that could only provide a single line of data, these new data cover a 75-mile-wide swath of the ocean surface giving us our first look at complex wave pattern never seen before. The satellite was able to image both the leading edge of the tsunami and the turbulent waters behind it. One of the surprises was a braided pattern of currents behind the tsunami front showing that tsunamis are dispersive. Our general picture of tsunami propagation before SWOT was that tsunami velocity depended only on the water depth and the wavelength and source characteristics made no difference. The new data suggests otherwise; tsunami wavelength can affect velocity and interaction between the different waves and create turbulence.

The SWOT data also shows a large source region that the DART instruments had predicted. The satellite path was able to map in detail the surface water bulge at the front of the tsunami that is a direct result of the seafloor deformation during faulting. The bulge extended roughly 60 miles longer than other methods had determined. This data can be used to modify tsunami propagation models and better constrain likely tsunami impacts on coastal communities like ours on the North Coast.

As huge as it was, the Kamchatka earthquake and tsunami caused few injuries and no deaths directly due to the event. One death and 25 injuries were noted in Japan, related to evacuation mishaps. This is also an important lesson. To survive a tsunami, people in harm's way need to evacuate, but evacuation also poses risk. The challenge is to refine assessments of the tsunami hazard area for specific events and finetune messaging and response to those who are really in danger. It's a tall order because under evacuation can have deadly results.

Thirty-two earthquakes caused at least one death in 2025 for a total of roughly 8,000, well below the ~30,000 average annual casualty rate since 1970. This average is distorted by a handful of truly horrific earthquakes. Perhaps more meaningful is the median value, which is just under 4,000 per year, making 2025 more deadly than most but far behind 2023 (64,000 deaths) and 2010 (~160,000). Like most years, it was the few catastrophic earthquakes that wreaked the most damage. Last year's top-of-the-leader-board events were in Myanmar and Afghanistan and accounted for 95% of the 2025 quake death toll.

The March 28 M7.8 earthquake in Myanmar (Burma) was centered on the Sagaing fault, an 870-mile-long strike-slip fault with similarities to the San Andreas fault. The high casualty numbers can only partly be blamed on poor construction. The earthquake was centered only a few miles from Mandalay, Myanmar's second largest city, where many of the buildings are constructed to standards similar to those in California.

The earthquake caused damage as far away as Thailand, SW China, and Vietnam. A collapse in Bangkok of a building under construction should get our attention. The building, over 600 miles from the epicenter, was 30% complete at the time of the earthquake and suffered total failure, killing 95 people at the construction site. It was the only structure severely damaged in Bangkok. Post earthquake investigations pointed to a substandard steel bar. The collapse highlights vulnerabilities of buildings under construction and the need for thorough oversite.

The ground motions and collapse in Bangkok may have been exacerbated by two features of the earthquake that are relevant in California. The first is supershear, rupture propagating along the fault faster than the speed of shear waves in rock. All seismic waves travel at speeds of a few miles per second, but supershear ruptures are even faster, creating a sonic boom like cone of concentrated side-to-side vibrations that enhance the most damaging seismic waves. The second is a smooth fault zone that transfers energy very efficiently to the surrounding area. The Sagaing fault, like the San Andreas, has been around for over 15 million years and has experienced thousands of large earthquakes, smoothing off bends and rough edges. Both supershear and highly efficient energy transfer could well be in play for the next significant San Andreas earthquake.

On August 3, a M6.0 earthquake struck northeaster Afghanistan, killing over 2,200 people. This was a tragedy on multiple levels, poorly built structures, poverty, inadequate infrastructure, feeble response and civil disruption. Even the time of day conspired against residents of the region. Striking just before midnight local time, most people were in their homes built of adobe and rock that easily collapsed. Proscriptions against international aid severely hampered relief efforts. Five months after the earthquake, many people are still displaced and living in tent shelters, despite harsh winter conditions.

On a brighter note, Taiwan continues to show mitigation efforts can reduce earthquake losses. Three earthquakes in the M6 range struck the east coast of the island, only miles from population centers with little damage and few injuries. In 2024 a 7.4 hit this same region with only minimal losses. The aggressive renovation of structures, elimination of wood in building, and beefing up response efforts continues to pay off.

Check out NASA's video and tsunami animation as SWOT passed over the Kamchatka tsunami https://science.nasa.gov/earth/earth-observatory/swot-spots-tsunami-wave-after-kamchatka-quake-154666/.

Lori Dengler is an emeritus professor of geology at Cal Poly Humboldt, and an expert in tsunami and earthquake hazards. The opinions expressed are hers and not the Times--Standard's. All Not My Fault columns are archived online at https://kamome.humboldt.edu/taxonomy/term/5 and may be reused for educational purposes. Leave a message at (707) 826-6019 or email Kamome@humboldt.edu for questions and comments about this column or to request copies of the preparedness magazine "Living on Shaky Ground."