

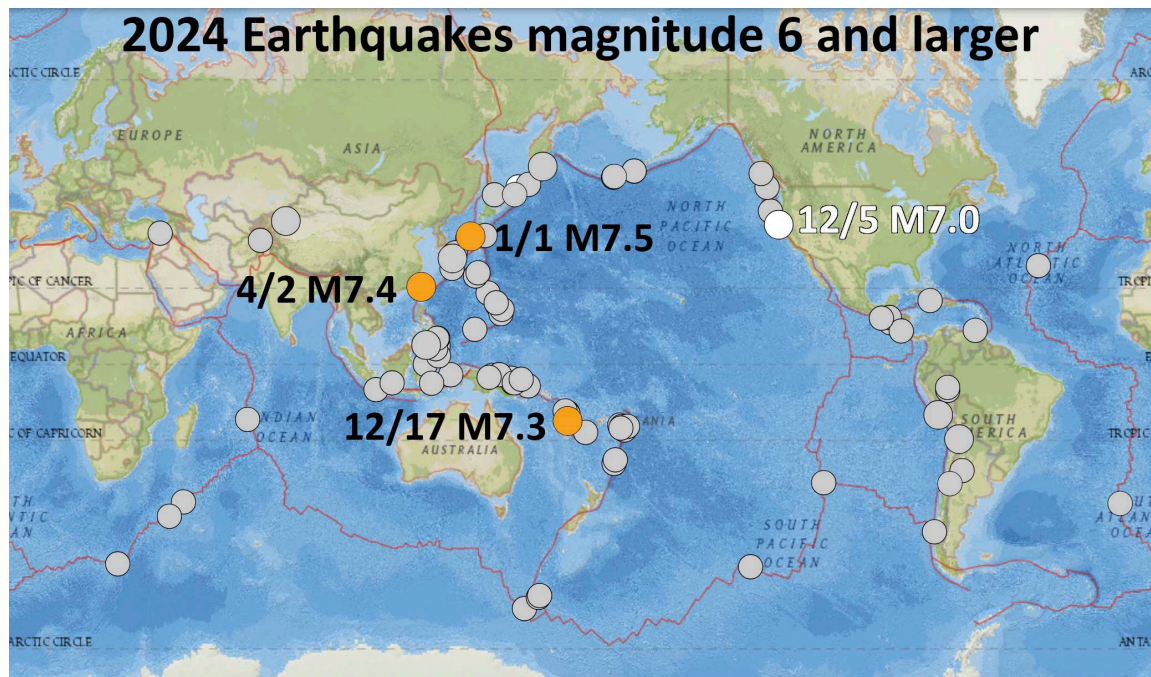
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Not My Fault: The earthquake story of 2024

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Global quakes of magnitude 6 and larger reported by the USGS in 2024. The three earthquakes that caused ten or more fatalities are shown in orange; white marks the location of the December 5 M7.0 Cape Mendocino earthquake.

2024 was a benign earthquake year with one notable exception. The January 1 Noto earthquake in the Sea of Japan claimed 504 lives, caused more than 1,300 injuries, and damaged nearly 180,000 structures in Japanese prefectures along the Sea of Japan. Economic loss estimates range between 7 – 17.6 billion (US \$). No other earthquake of 2024 came close to the impact of the Noto quake. Only 57 other earthquake deaths were tallied elsewhere on the globe last year.

The Noto earthquake has lessons for us in California. Unlike the M9.1 2011 Great East Japan earthquake, it did not occur on a subduction fault and at magnitude 7.5, is not considered a “great” earthquake. Japan, like California, has many faults not on plate boundaries that are quite capable of producing earthquakes in the magnitude 6 to 7 range and causing major damage.

We tend to fixate on the “big one,” the largest magnitude earthquakes on the planet. There is reason to be concerned about megaquakes in the M8.5 to M9.5 range - they have a much larger footprint for causing shaking damage and are often accompanied by major tsunamis. But these earthquakes are relatively uncommon compared to those of lesser magnitude and often don't

cause as many casualties. It's earthquakes like the Noto quake and the 2023 Turkey doublet (M7.8 & 7.7 ~60,000 deaths), that year in and year out account for the most carnage.

Japan is known for its advanced seismic engineering and modern building codes. But, like California, many older buildings have not been retrofitted, especially in smaller cities and towns, and are still vulnerable to collapse in strong ground shaking. There is much unstable ground in Japan, and structural collapse was exacerbated by numerous ground failures triggered by shaking.

Like California, most structures in less urban areas are of wood construction, but unlike our homes, traditional Japanese houses are often topped by heavy tile roofs. This construction style evolved over hundreds of years as a way to prevent roof damage in typhoons but makes them top heavy and more susceptible to collapse in earthquakes. But our shared wood-frame communities make both of us vulnerable to post-earthquake fires.

Fires are a deadly offshoot of many earthquakes and can be triggered by broken fuel lines, overtopped stoves, and electrical sparks. The Noto earthquake was no exception. A major fire broke out 50 minutes after the earthquake, ultimately burning nearly 12 acres on the Noto Peninsula. Firefighters were unable to respond effectively to the fire due to debris blocking roads, disrupted water supply, and the tsunami threat which prohibited responders from entering areas at risk of inundation.

Fire-prone communities are one of the biggest shared vulnerabilities in Japan and California. A similar-sized earthquake last year in Taiwan starkly points out the problem. On April 3rd, 2024, a magnitude 7.4 earthquake struck the east coast of Taiwan near the Hualien City. Strong shaking affected over 15 million people in Taiwan, more than three times the number as in Japan, yet only 18 deaths were reported. A big reason for the much lower casualty numbers is efforts taken in Taiwan after the 1999 M7.6 that claimed 2400 lives, retrofitting many structures and replacing wooden buildings with concrete and steel.

Another important lesson from the Noto earthquake is how vulnerable people are AFTER the shaking stops. Fewer than half the total casualties on January 1st of last year are attributed to shaking or fire damage. Two people perished in the tsunami, but the remaining 276 fatalities are attributed to the aftermath – deaths due to injuries and illnesses in the days after the earthquake. Evacuation poses hazards and spending days and weeks in temporary housing or shelters has risk. Planning for safe evacuation and sheltering of displaced people is a big part of emergency management.

While tsunami warnings are fresh on our minds, it's useful to look at the Noto tsunami and compare it to our experience on December 5th. The preliminary magnitude determined by JMA (Japanese Meteorological Agency), was 7.5, not a lot larger than the 7.3 estimate made by the National Tsunami Warning Center (NTWC) after our earthquake. But JMA's tsunami alert was part of their earthquake early warning message sent to millions of cell phones only seconds after the earthquake rupture began and updated several times in the following minutes. In the US, tsunami warnings are not yet part of the ShakeAlert system and our first tsunami alert came out five minutes after the earthquake and was updated in half hour increments afterwards.

JMA is also able to estimate the relative tsunami threat soon after the earthquake. Given the size, location, and type of rupture, a major tsunami warning was issued forecasting water heights of 16 feet or more. A number of sites in the epicentral region met or exceeded this number, including a peak of nearly 24 feet at the city of Joetsu about 60 miles from the epicenter.

Why such a big tsunami for a M7.5 earthquake when our December 5th M7.0 hardly caused a ripple? The first difference - the Noto quake was on a reverse fault that caused vertical deformation of the sea floor while ours was on a strike-slip fault with horizontal slip. The second was a submarine landslide triggered by the Noto quake shaking.

It's easy to understand these difference in hindsight now that we have time to pour over the details of the earthquake and post-earthquake and tsunami investigations have been completed. But when a large quake strikes close to populated areas, NTWC only has minutes to make a call. We can't determine the fault rupture mechanism as quickly as JMA – in part because we don't have the offshore instrumentation. Current technology at NTWC doesn't have the ability for rapid forward forecasting of the likely tsunami size.

Underwater landslides are always a concern when strong shaking occurs near the coast. We know that our coastal bluffs are susceptible to failures even in the absence of shaking and offshore slopes such as the continental shelf and the Eel River and Trinidad canyons are similarly vulnerable. This was the main reason for the seventy minutes our tsunami warning remained in place. NTWC wanted to make sure that no offshore slope failures had occurred.

We share another similarity with Japan. We are both still experiencing aftershocks. The Noto quake has produced 160 earthquakes of magnitude 4 and larger since the mainshock, the largest a 6.2 on December 31st, nearly a year afterwards. Aftershocks will likely persist for many more months before finally returning to a "normal" background level. We can expect our aftershocks to continue for some time as well and don't be too surprised if our largest aftershock shows up months from now.

The Noto earthquake was not only the deadliest quake of 2024, it was also the largest. 2024 was notable for having relatively few large quakes. Only ten quakes of 7 or larger were reported last year the third fewest since 2000 and all of those other years had larger earthquakes. Fewer major quakes mean fewer large tsunamis. Of the ten tsunamis listed by NOAA's National Center for Environmental Information last year, the largest ones were triggered by landslides, not earthquakes.

I don't put much significance on our lower 2024 tally. Earthquakes don't recur on a clockwork basis. There have only been six years over the past 25 when no magnitude 8s were reported and three of them have been since 2021. Between 1946 and 1966 eight quakes of M8.5 and larger were reported followed by almost forty years of nothing larger than an 8.4. Since 2004, six M8.5 and larger earthquakes have occurred. I am hoping we are entering another four-decade quieter spell, but I wouldn't bet on it.

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