



Tsunami

A tsunami is generated when large volumes of ocean water are displaced. The most common cause (95%) of tsunami is thrusting of oceanic crust. However, large meteor impacts, underwater landslides and volcanic eruptions can also displace water. Tsunami is the deadliest and most widespread earthquake effect.

Making waves

Figure 1 shows the formation of a typical megathrust tsunami. Although shown as a point on a map, most tsunamis involve rupture along a stretch of fault many kilometres long. The run up and wave height vary with local topography. Narrow inlets may act to concentrate wave energy and create much higher waves and further run up.

Tsunami waves travel at the speed of a jet at sea. On land the velocity in Onagawa (2011 Tohoku event) was estimated at 6.3 m/s at a depth of 5m. This results in a drag force of 100,000 N/m acting on the walls of structures.



Figure 2. A mosque is left standing in the rubble of Banda Aceh after the Boxing Day tsunami in 2004. Mosques often have an open ground floor this helped it withstand waves that reached the middle of the second floor. (USGS 2005, public domain)

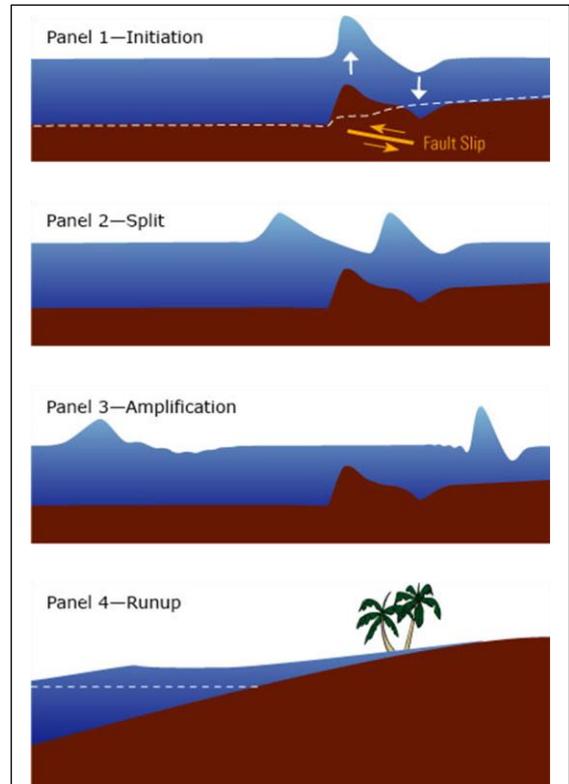


Figure 1. Life of a tsunami, based on a megathrust earthquake. Wave heights are exaggerated.

- 1 – Rupture of the seafloor pushes water up in a tsunami.
- 2 – The tsunami splits into a wave that travels to deep ocean and another travelling to nearby coast.
- 3 – As the tsunami travels up the continental slope, the height increases and a trough pulls back water from the shore
- 4 – The tsunami travels up onto shore well above normal sea level. Most tsunamis do not generate breaking waves like the 2004 and 2011 events. Instead, they surge inland like strong tides.

(USGS, Life of a Tsunami, public domain)



Notable tsunamis 2000-2019

| Location, date | Cause | Distance of damage | Tsunami Impact |
|-------------------------------|---|--|---|
| Sumatra, Boxing Day 2004 | Magnitude 9.1 quake displaced 30 km ³ of water, causing a 10 m wave that surged up to 30 m. A 1,200 km stretch of the Indian plate was thrust up under the Burma plate. | Tsunami devastated Indonesia, Sri Lanka, Thailand, the Philippines and East Africa. The furthest deaths were swimmers in South Africa. Effects were noted in Antarctica and North America. | Caused more than 225,000 deaths across 14 countries. Up to 5 million people lost homes or access to food and water. 500,000 were injured. |
| Solomon Islands, 2 April 2007 | Magnitude 8.1 quake along a 260 km stretch where the Australia/Woodlark/Solomon Sea plate subducts beneath the Pacific plate. | The tsunami swamped buildings, swept away villages and dragged people out to sea in the Solomon Islands. Some areas of Papua New Guinea were also affected. | At least 52 people died and thousands were left homeless. Waves had a run up of 12 m on northern Simbo Island; 10 m in South Choiseul. The island of Ranongga was lifted 3 m by the earthquake, exposing large areas of coral reef. |
| Samoa, 29 September 2009 | Magnitude 8.1 quake on the outer rise of the subducting plate at the Tonga-Kermadec subduction zone (unusual mechanism). The earthquake occurred along a 100 km stretch of normal faulting. | Affected Samoa, American Samoa, Tonga, Cook Islands, Fiji, French Polynesia and New Zealand. | Waves were up to 6 m high and reached inland up to 1.6 km. More than 189 people were killed. Critical infrastructure (power, water) was damaged in Samoa. |
| Tōhoku, 11 March 2011 | Magnitude 9.1 quake associated with thrust faulting along 400km of the subduction boundary between the Pacific and North American plates. | 561 km ² along Pacific coast of Japan was inundated, with water extending up to 10 km inland. The tsunami was 2 m high in Chile, 17,000 km away. Debris washed up as far away as North America. | The Honshu coastline dropped by 0.6 m and wave heights were up to 10 m. More than 15,000 people died and nearly 3,000 were missing afterwards. More than 130,000 buildings collapsed or washed away. The Fukushima Daiichi Nuclear Power Plant was damaged, causing a nuclear disaster. |

Resourced by





Sulawesi, 28
September 2018

Magnitude 7.5 quake along a 150km strike-slip fault 70 km from Palu. This triggered vertical seafloor movement and underwater landslides.

The tsunami impact was localised to Palu Bay. The earthquake itself caused extensive liquefaction and damage.

The narrow inlet near Palu caused wave heights of up to 7 metres and reached up to a kilometre inland. More than 800 people died from the tsunami and more than 2,000 for the entire event.

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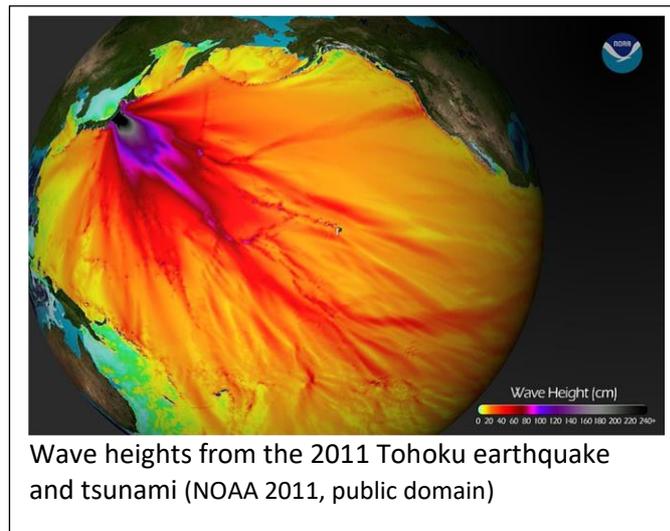
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Wave heights from the 2011 Tohoku earthquake and tsunami (NOAA 2011, public domain)