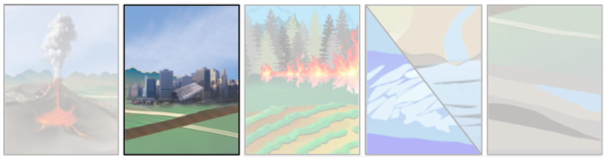
NISAR: The NASA-ISRO SAR Mission



Earthquake! Tracking Location and Impact from Space

Earthquakes occur suddenly, often with intense ground shaking that causes loss of life and property. They and their aftershocks can induce landslides, lead to fires, and even bring neighboring faults closer to rupture. NISAR will provide measurements of ground deformation along faults before an earthquake occurs, from the earthquake itself, and in the time following, all key information for understanding where and why earthquakes occur.

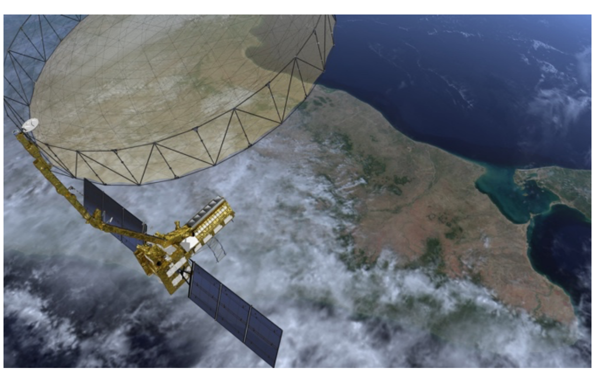
Earthquake Hazards in the United States and Around the World

Earthquakes in the United States are estimated to cost about $5.3B annually (FEMA, 2008). Earthquakes can damage buildings and critical infrastructure, rupture gas and water lines, cause landslides, and create liquefaction. Sedimentary basins can amplify earthquake shaking, even for distant earthquakes: The 1985 Mexico City earthquake occurred 350 km from the city, but because the city is located on an ancient lakebed, it experienced intense shaking, killing thousands of people. Subduction zone earthquakes that originate offshore can create tsunamis, resulting in further damage and loss of life: The 2011 M9.0 Tōhoku-oki earthquake offshore of Japan created tsunami waves reaching as much as 130’ high. Landslides and fires are additional hazards that cascade from earthquakes: Fires broke out after the 1906 M7.9 San Francisco earthquake destroying much of the city.

Photos: USGS

Plate Tectonics and Earthquakes

Movement of Earth’s tectonic plates causes strain to accumulate in the crust, which eventually drives faults to rupture. Following major earthquakes, the ground continues to deform and aftershocks occur as the crust responds to the changes in stress. Surface motion in the area around an earthquake fault are measurable throughout this entire earthquake cycle of loading, rupture, and recovery.



The NISAR Mission – Reliable, Consistent Observations

The NASA–ISRO Synthetic Aperture Radar (NISAR) mission, a collaboration between the National Aeronautics and Space Administration (NASA) and the Indian Space Research Organization (ISRO), will provide all-weather, day/night imaging of nearly the entire land and ice masses of the Earth repeated 4-6 times per month. NISAR’s orbiting radars will image at resolutions of 5-10 meters to identify and track subtle movement of the Earth’s land and its sea ice, and even provide information about what is happening below the surface. Its repeated set of high-resolution images can inform resource management and be used to detect small-scale changes before they are visible to the eye. Products are expected to be available 1-2 days after observation, and within hours in response to disasters, providing actionable, timely data for many applications.

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Earthquakes can occur in many parts of the world, but nearly 90% happen along the Ring of Fire, the area around the rim of the Pacific Ocean where most active volcanos lie. The Ring of Fire includes Japan and California, both parts of the world where earthquakes are frequent occurrences.

When an earthquake fault ruptures, seismic waves radiate away from the fault causing ground shaking along their path. It is common for this seismic shaking to trigger landslides and to indirectly induce fires. Understanding the likely scale and location of future large earthquakes is therefore an important ingredient in preparing for them and reducing the loss of life and property.

Faults generally slip continuously deep within the Earth, but near the surface the faults can be 'locked' or 'clamped,' and do not move continuously. These shallower locked portions are the source of the earthquakes we feel. The deep fault slip manifests at the surface as small shifts in the ground, or deformation, that is localized around the faults. Detection of areas with higher rates of deformation can be used to identify active faults. The rate of slip across the fault, depth at which the fault becomes locked, and the length of the rupture all contribute to the magnitude of an earthquake, with larger slip and longer ruptures resulting in more powerful earthquakes. Therefore, determining long-term slip rates on faults and other characteristics is key to forecasting earthquake hazard.

Earthquakes are usually the result of tectonic processes; however, they can also be induced by human activity. Such 'induced' seismicity can be the result of geothermal operations, hydraulic fracturing to extract oil and gas, injection of wastewater, and large changes in the stored water at water reservoirs, particularly from water in dams.

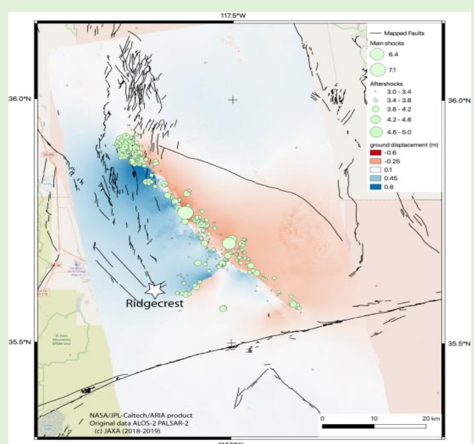
The larger induced earthquakes are typically associated with injection of wastewater used to aid the extraction of oil and gas from underground reservoirs. The injection of water increases pore pressure in the rock and can interact with an existing fault, triggering an earthquake. The injection of fluids can cause measurable uplift or subsidence of the ground surface.

Deformation measured with NISAR will help in mapping fault zones and fault systems around the world and detecting subsidence and uplift associated with human activity. This information is obtained before an earthquake happens and provides insight into how they will behave. Following earthquakes, NISAR will identify earthquake ruptures and measure the amount that the ground slipped along the faults, mapping the length of the rupture and providing an indication of damage extent. NISAR will be used to locate areas of damage to roads, buildings, and other structures, and provide information about other disasters triggered by the earthquake

Earthquake fault motion and damage

In 2019 two earthquakes occurred near the town of Ridgecrest and the China Lake Navy facility in southern California. A M6.4 earthquake on July 4, 2019 was followed by a M7.1 earthquake on July 5, 2019 about 34 hours later. The two faults ruptured nearly perpendicular to each other. Radar can be used to measure permanent ground displacements associated with earthquakes as well as continued motions as faults continue to slip aseismically after large earthquakes. Surface disruption can also be measured with radar providing a proxy of where specifically damage occurs to buildings.

The image at right shows the ground displacements from the 2019 Ridgecrest earthquake sequence. Motions can be detected in an area about 60 km long and 40 km wide.



Ross et al., Science, 2019
Fielding et al., Seismological Res. Lett, 2020

Radar-derived map of ground movement near Ridgecrest, California, following magnitude 6.4 and 7.1 earthquakes in July 2019. Areas west of the main fault rupture (blue) moved northwest while areas east of the fault (red) moved southeast. Black lines show mapped faults.