Earth is a dynamic planet, constantly changing and evolving since its formation. Beneath its surface lies a powerful convection system that drives the movement of tectonic plates, giving rise to earthquakes, volcanism, and the formation of mountains and associated hazards, such as landslides.

Today, more than 1 billion people live in areas that could be significantly impacted by volcanic eruptions, earthquakes, and landslides. Along the West Coast of North America, there are active faults and volcanoes near major cities. In mountainous regions, there are significant landslide hazards, which may further increase due to extreme rainfall associated with climate change. As the population increases, so does society's vulnerability to geological disasters. Measurements from radar satellites can help society prepare and formulate science-based decisions to reduce risk.
Geodesy is the science of accurately measuring the dynamic surface of the Earth. By monitoring the changes in Earth’s size, shape, orientation, and microgravity, we can understand natural processes that occur — even at depth!

Tectonic plates are constantly moving, converging, separating or grinding past each other. The boundaries between plates include fault zones that can: 1) slowly move or “creep” for long time periods or 2) get stuck due to friction and accumulate stress. These "locked" faults are capable of generating large earthquakes. Although it is not yet possible to predict the exact timing and location of earthquakes, identifying and monitoring locked and creeping fault segments are crucial. This information will help us prepare not only for “the big one”, but will also guide policy makers to develop better building codes and guidelines, and aid engineers in designing infrastructures.

Volcanic eruptions can cause dramatic changes to the Earth’s surface and atmosphere that can persist for months or years and extend far beyond the volcano itself. Fortunately, most volcanoes exhibit precursory signals prior to eruptions. Timely detection and analysis of these signals allow eruptions to be anticipated and communities at risk alerted. One powerful precursory signal is ground deformation, often linked to the subsurface movement and storage of magma and gases. By tracking the movement of the ground, scientists can characterize and forecast the behavior of volcanoes, including the potential magnitude of eruptions.
Like faults and volcanoes, landslides also cause changes in the Earth's surface that can be identified and monitored with interferometric SAR (InSAR). Some landslides move slowly, similar to creeping faults, while others accelerate rapidly and travel large distances. In both cases, damages to infrastructure or life are possible. InSAR can be used to measure these slow and/or precursory motions of the ground surface and track landslide activity through time. This key information will help enable the development of best practices and potentially lead to new and improved early warning systems for landslides. Regularly acquired radar satellite data (e.g., currently between 6-12 days with Sentinel-1) over a given region can constrain centimeter-scale deformation processes with unprecedented spatial resolution, day and night, rain or shine. OPERA's DISP products are derived using growing archives of InSAR observations from Sentinel-1 A/B and NISAR. These products can provide continuous data to the community and will enable us to better understand Earth's processes related to volcanoes, earthquakes, landslides, and more!

Did you know?
The 2018 Kilauea eruption in Hawaii was the largest eruption and caldera collapse experienced by the volcano in 200 years. Over 1.0 cubic kilometer of lava was erupted from May to August 2018 covering 35.5 square kilometers of land (Neal et al, 2019)! During the eruption, scientists used multiparametric datasets including InSAR to better understand the eruption as it progressed. InSAR can be used to monitor the movement of the ground, formation of new eruptive fissures, and even map the emplacement of lava flows by comparing before and after radar images.