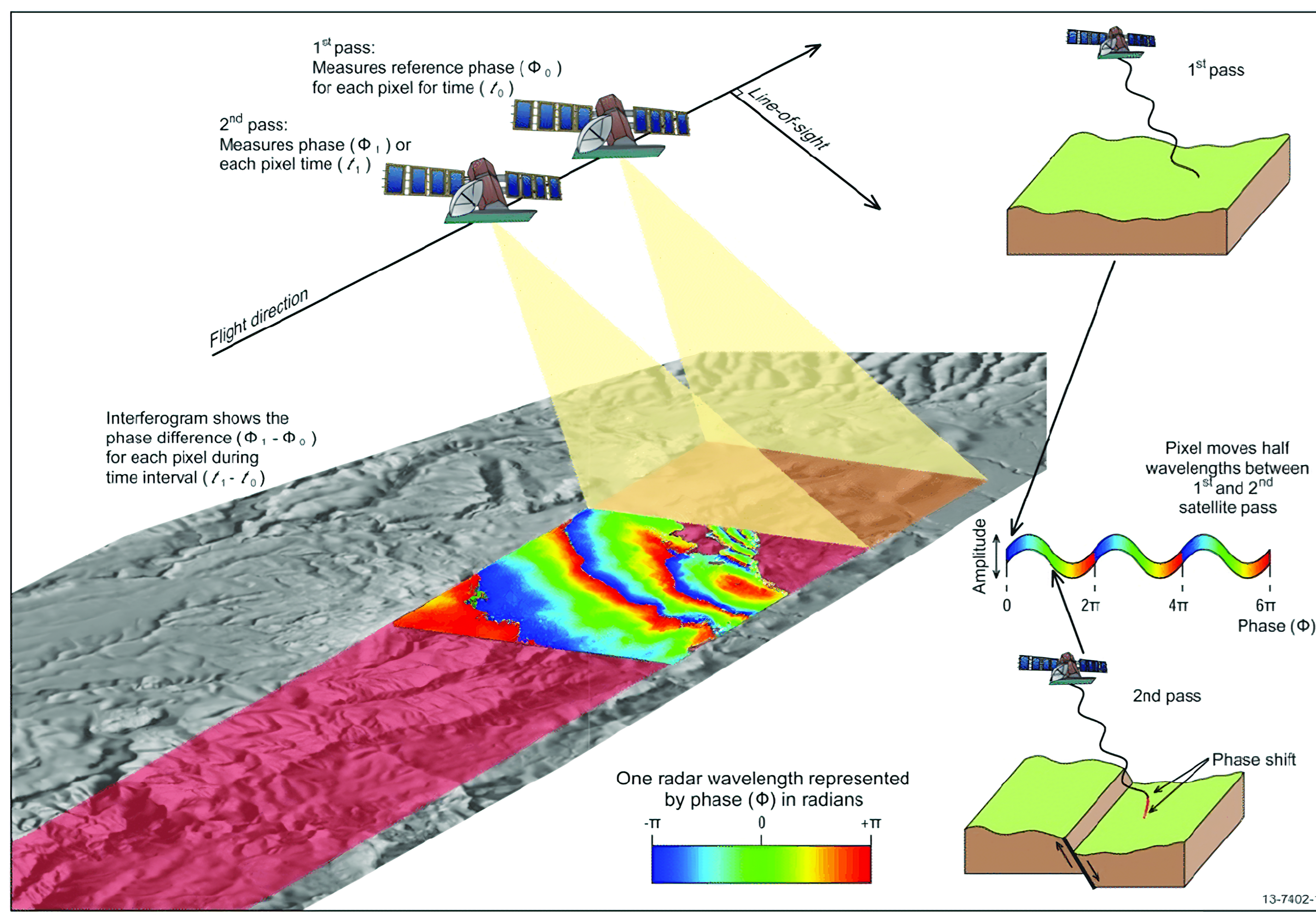


# Sentinel-1 sensor for landslides and earthquakes

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## 1. Sensor description

Sentinel-1 is a European radar satellite mission under Copernicus, a program run by the European Commission and the European Space Agency (ESA). They use two active C-band SAR sensor (synthetic aperture radar), placed in an orbit at 693km, that collects data in all weather during days and nights, through 4 different modes, and enables the detection of subtle ground movements, crucial for monitoring earthquakes, landslides, volcanic activity, and land subsidence. **Interferometric Wide Swath (IW)** or **Stripmap (SM)** modes are usually used for those applications. The **Interferometric SAR (InSAR)** technique enables the measurement of earth displacement.



**Figure 1:** Two SAR images of the same area are acquired at different times. If the surface moves between the two acquisitions a phase shift is recorded. An interferogram maps this phase shift spatially [3].

Some numbers:

- **Resolution** down to 5m
- **Coverage** up to 400 km swath width (ex: 80km for SM and 250km for IW)
- **Revisit time** between 6 and 12 days due to the two satellite constellation orbiting 180° apart.
- **Bandwidth** 0-100 MHz

## 2. Applications & Challenges

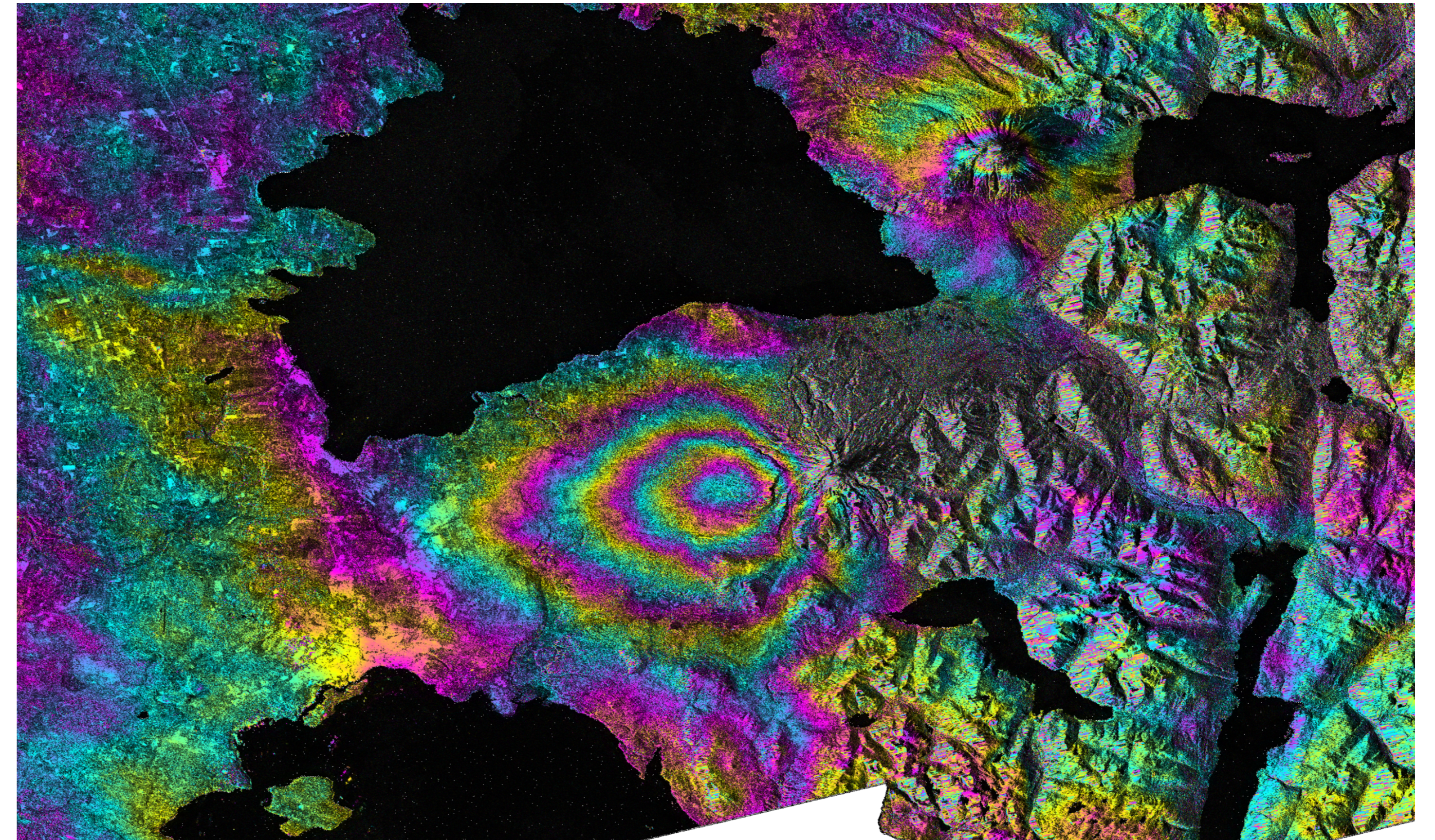
Sentinel-1 data are particularly valuable for the observation of natural hazards, with notable applications in the study of earthquakes and landslides.

– **Earthquakes:** InSAR offers the capability to generate medium to high-resolution maps of earthquake-induced deformation. By enabling the persistent monitoring of seismically active regions, it supports the identification of fault lines and the assessment of associated risks. The IW mode facilitates the observation of large-scale seismic events, while the preservation of phase information makes the Single Look Complex (SLC) product type essential for interferometric analysis.

– **Landslides:** SAR interferometry is widely applied to identify slopes prone to landslides and to monitor ground deformation over time. Repeated observations make it possible to track slope instabilities, detect reactivation episodes, and map the extent of mass movements. These capabilities provide valuable information for early warning systems, risk assessment, and the protection of critical infrastructure in landslide-prone regions.

**Challenges:** Monitoring earthquakes and landslides with Sentinel-1 faces several limitations. Atmospheric disturbances can blur subtle deformation signals, while steep terrain causes geometric distortions that reduce accuracy. Vegetation may hide surface changes, and rapid landscape evolution leads to signal decorrelation. Finally, large data volumes and complex processing demand significant computational resources and expertise.

## 3. Sentinel-1 for geohazards



**Figure 2:** Ground deformation from Chile's Calbuco volcano eruption (April 2015) captured by ESA's Sentinel-1 radar satellite, processed by NASA/JPL—showing subsidence from a deflating magma reservoir.

Thanks to its radar capabilities, observation frequency, and sensitivity to ground deformation, the Sentinel-1 mission is well suited for landslide and earthquake applications, making it an effective tool for geohazard monitoring.

The main advantages of Sentinel-1 can be grouped into the following categories:

### 1) Observation capability

- (a) Active radar sensor (SAR) – independent of sunlight
- (b) Works day and night
- (c) All-weather imaging (penetrates clouds, rain, smoke)

### 2) Measurement sensitivity

- (a) Detection of land subsidence with InSAR
- (b) C-band wavelength (5.6 cm) well-suited for surface deformation studies

### 3) Coverage and revisit

- (a) Wide IW swath (up to 250 km)
- (b) Frequent revisit (6–14 days depending on region)
- (c) Enables time-series analysis for slow or progressive hazards

## 4. Conclusion

Sentinel-1, with its C-band radar, is a powerful tool for landslide and earthquake monitoring, offering all-weather, day-and-night imaging and millimeter-scale deformation detection for science and risk management. Its effectiveness has been demonstrated worldwide, such as in mapping surface displacement after the 2015 Nepal earthquake, monitoring slope instabilities in the Alps, and rapidly assessing ground deformation during the 2023 Turkey–Syria earthquake. These examples highlight how Sentinel-1 not only advances geohazard research but also supports early warning systems and post-disaster response, ultimately helping to reduce risk and prevent further damages.

## References

- [1] Copernicus. S1 mission - copernicus program.
- [2] ESA. Sentinel-1 captures ground shift from myanmar earthquake.
- [3] Australian government. Interferometric synthetic aperture radar. *Geoscience Australia*, 2017.