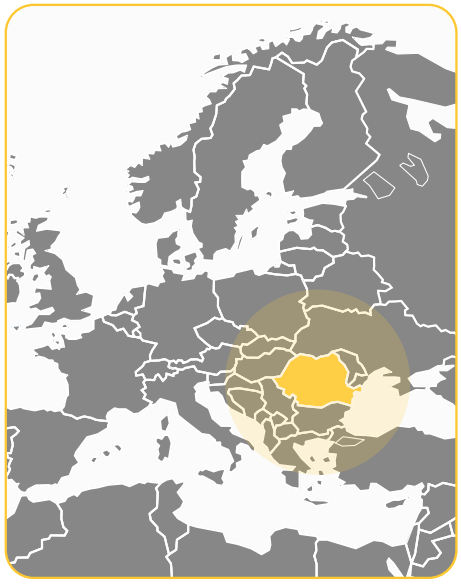
European Union

GROUND MOTION INTELLIGENCE IN ROMANIA

Sentinel data is being used to investigate causes and processes of extended landslides in Romania

THE CHALLENGE

Romania boasts some of Europe's most spectacular scenery, from the expanses of the Carpathian Mountains to the rolling hills and ancient castles of Transylvania. These dramatic landscapes were formed from ancient geological activity in the region, which also brings with it many hazards. This Eastern European country is severely impacted by a variety of natural hazards, such as earthquakes, floods, landslides, and soil erosion, all of which have extensive social and economic repercussions. However, typically the most common environmental disaster experienced in Romania are landslides.



Landslides are geological phenomena that involve the unexpected movement of soil, rock, or debris. In response to specific geological events, such as seismic disturbances or heavy rainfall, these hazardous movements can occur, sometimes leading to flooding. Landslides are, in fact, a significant driver of land degradation. Utilising sustainable land-use practices, such as reforestation, soil conservation, and effective land management can reduce landslide frequency while simultaneously protecting natural habitats, vital infrastructure and saving lives.

Approximately 42% of Romania's terrain harbours landslide-triggering conditions. The most vulnerable regions are those rich in fragmented sedimentary materials like clay and marl, an earthy material rich in clay or silt. Within these areas, over 50% of the slope surfaces are susceptible to landslides and mudflows. Landslides mostly occur in the Moldavian and Transylvanian tablelands.

In fact, as recently as earlier this year the areas of Central and Northern Romania were severely affected by extensive floods that prompted numerous severe landslides and road damage. This past January, Bistrita and Maramures were among the most severely struck counties, with the need to rebuild a €2 million section of road that had been previously funded by the EU. Other floods in June also caused landslides in Arad County in the west of the country, resulting in the destruction of dozens of houses and the unfortunate loss of one life. Thankfully, satellite data can help in understanding and preventing issues related to extended landslides with various movement dynamics in the future.

More information on **www.earsc.org/sebs**

HOW SATELLITES CAN HELP

Geo-Sentinel Ltd. is a Hungarian company offering deformation monitoring services, spanning from regional tectonic analyses to inspecting individual infrastructures. They ensure comprehensive monitoring through the use of numerous cutting-edge space geodetic techniques, like satellite-based Synthetic Aperture Radar interferometry (InSAR), and Global Navigation Satellite Systems (GNSS) measurements. Geo-Sentinel's high-precision deformation studies yield insights into natural phenomena and several human-induced activities, which are vital to understanding natural hazards and strategies to manage and protect infrastructures. Its applicability further extends to other domains, such as mining-related activities, construction works, oil, gas and groundwater extractions, etc.

In this case, Geo-Sentinel primarily used Sentinel-1 to investigate the presence of landslides close to a mining operation in Romania. Thanks to Sentinel-1's continuous and weather-independent capabilities, radar satellite technologies have demonstrated their usefulness in monitoring the continuous landslides. Sentinel-1 carries a Synthetic Aperture Radar (SAR) instrument which emits microwave pulses and records the echoes from each pulse. The distance between the satellite and the ground measurement point is determined by the time it takes for the echo to arrive. The main approach used for data processing is Multi-Temporal Interferometry (MTI). Using MTI, the distance between known sites is compared by contrasting successive SAR images (InSAR). When these have changed, the radar can identify it. Geo-Sentinel complemented their use of Sentinel data with commercial data in order to further refine the deformation analysis.

Expanded use of low-cost remote sensing data can be advantageous for the analysis of ground deformation or movement across several sectors. Sentinel-1 data allows users to ensure a more comprehensive and effective use of InSAR for worldwide infrastructure surveillance.

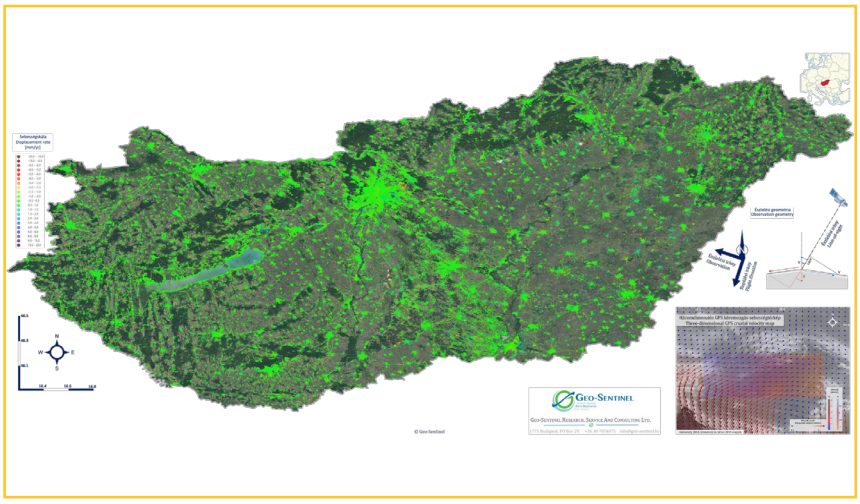


Figure 2. First ground motion map of Hungary.
Source: Geo-Sentinel.

The satellite data:

Sentinel-1 is the Copernicus radar mission, providing an all-weather, day-and-night supply of imagery of Earth's surface.
The mission consists of two satellites embarking C-band synthetic aperture radars (SARs) in continuity of the ESA's ERS-2 and Envisat missions. The mission images the entire Earth every six days for the benefit of manifold applications such as monitoring of Arctic sea ice extent, surveillance of the marine environment, monitoring land-surface for motion risks, mapping for forest, water and soil management.

Copernicus Sentinels data are available under an open and free data policy.

Sentinel-1 data can be accessed at

https://dataspace.copernicus.eu

The Service Provider

Geo-Sentinel has been carrying out national and international scientific research and development projects for over 20 years.

They conduct space-based geodetic research as well as industrial projects and performs monitoring services for a wide range of domestic and foreign customers; they have worked with research institutes, private companies, and the public administration.

GEO-SENTINEL

https://geo-sentinel.eu/

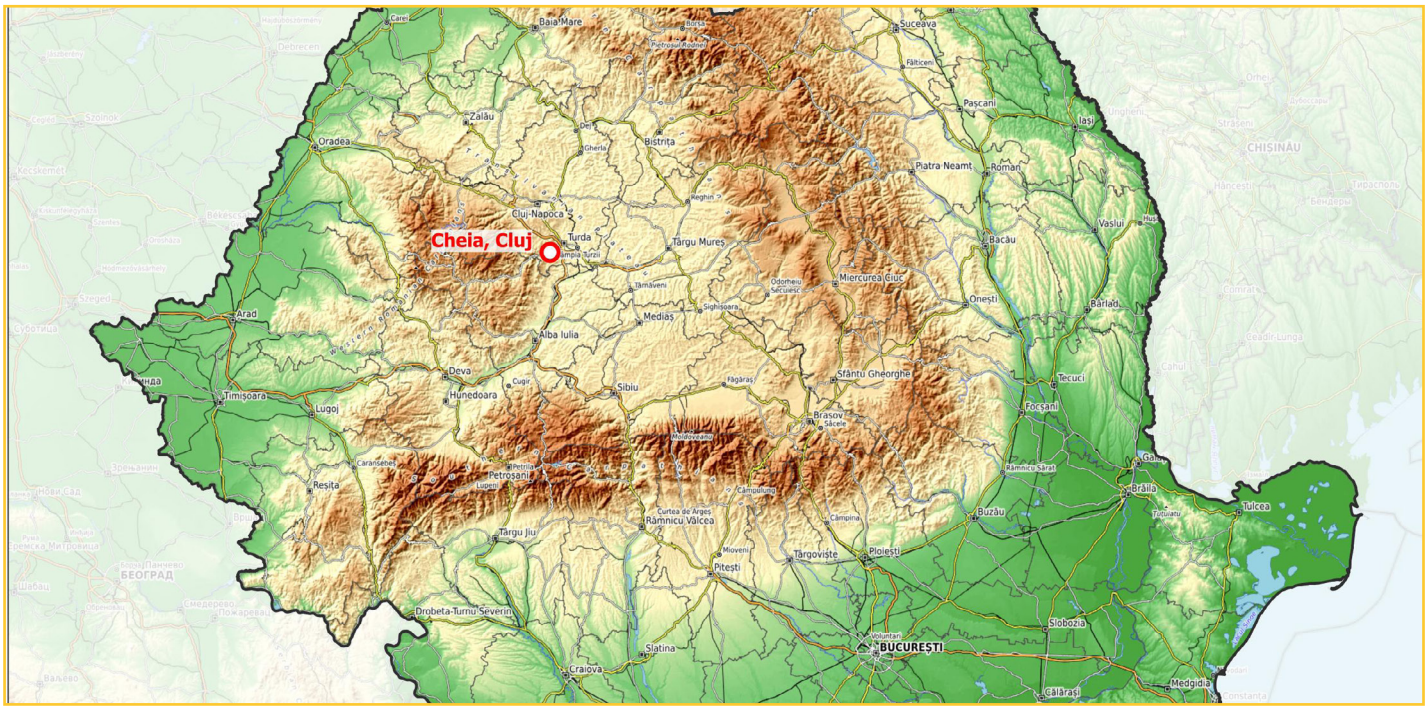


Figure 3. Romanian physical map. Source: OpenTopoMap, Geo Search

WHO IS CONCERNED?

Geo Search SRL is a Romanian company that specialises in geotechnical studies, usually complemented by technical support activities such as ground monitoring or consultancy.

One of their main activities consists of analysing slope stability, which is crucial in understanding the causes of landslides and preventing the onset of movements, taking measurements to reduce the risks and hazards of potential landslides including the significant damage they can cause. To do so, geotechnical studies are carried out, which provide pivotal data to examine the land in question and its potential construction design. Geotechnical studies are vital for cost-effective construction and involve subsoil exploration (drilling, in-situ field tests), characterizing soil conditions (analysing soil samples, groundwater) and the use of various monitoring systems (inclinometers, piezometers, geodesy, InSAR).

With particular relevance to this case, ground movement had been occurring around the town of Cheia, near Turda in Romania for over a few centuries. Geo Search was hired by a Romanian mining company which had been conducting surface mining works near Cheia to see if their operations were contributing to the existing issue. Geo Search was able to perform in-situ investigations and acquire a holistic overview of what had transpired. However, in order to get a full understanding of the ground movements, including their extent and distribution in the studied area (Cheia village and its surroundings), as well as their temporal dynamics correlated with weather data, Geo Search hired Geo-Sentinel to perform remote analysis using Sentinel data.

Thanks to the data available from Copernicus, Geo Search and its client could better understand the causes and history of ground deformation in the area, helping Geo Search's client to plan future mining works according to the findings of the study.

The Primary Users

Headquartered in Cluj-Napoca, the Romanian company Geo Search has been providing geotechnical services for 17 years.

Their services span from preparing exploration programmes to establishing designing solutions.

Regarding slope stabilisation and landslides, they carry out analyses to determine which of their array of solutions should be applied.

GeoSearch®

https://geosearch.ro/

WHAT ARE THE BENEFITS?

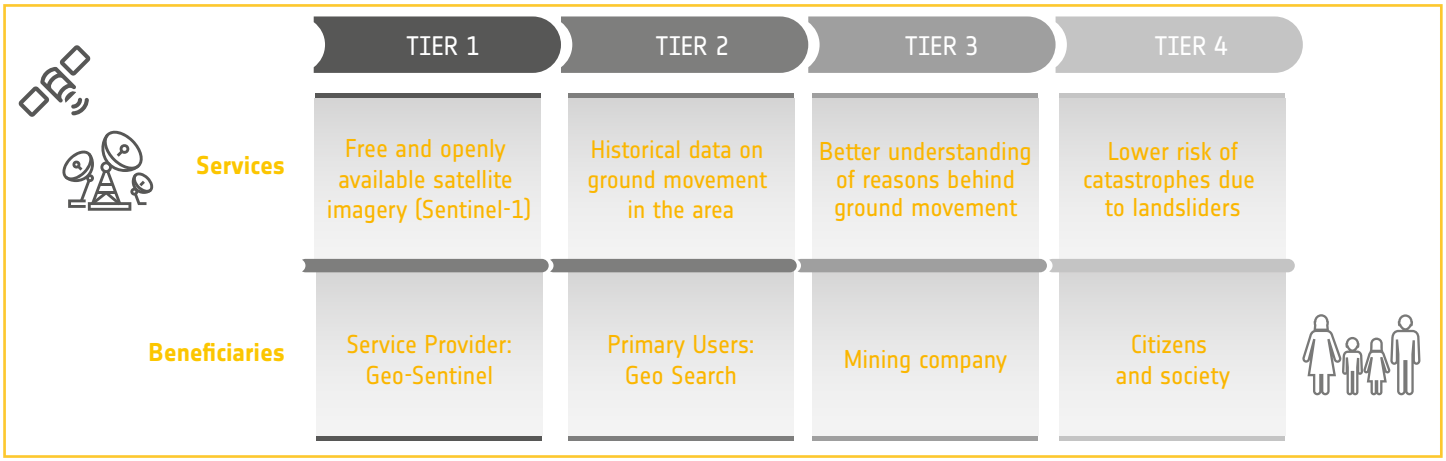


Figure 3: Value chain of the main stakeholders and beneficiaries

Copernicus data benefits the stakeholders in this case in several ways. Firstly, Sentinels offer "hands-off" measurement capabilities, reducing the need for on-site instruments like inclinometers or intrusive measurement techniques. This means checks on ground motion can be done over large areas in sustainable and ecologically friendly ways.

An essential early warning system is also provided by this satellite-enabled service. Through continuously monitoring landslide-prone locations, timely notifications can be utilised to carry out evacuation plans and save lives. Additionally, the information they produce helps in preparedness and reaction to disasters, ensuring public safety. The data also aids in the planning of mining operations and land use policies, which lowers the likelihood of catastrophes brought on by landslides.

There are notable economic benefits. Sentinel data provide precise and current information, which helps safeguard vital infrastructure like buildings, railroads, and roads. Consequently, this lowers the price of reconstruction and repair. Also, thanks to the free and open nature of Sentinel data, service providers could reduce commercial data purchasing costs.

Finally, Sentinel data helps ensure that all mining operations are within the requirements of regulatory compliance by supplying vital information to mining companies on the potential impacts of their activities.

Societal

Decisions related to lawful liability can be based on better, more objective evidence, leading to fairer dispute resolutions (All Tiers)

Environmental

They enable remote, hands-off monitoring to safeguard ecosystems from landslides, reducing on-site instrument reliance and promoting sustainable resource management (Tier 4).

Economic

Overall savings for the mining company are associated to reduced repair and reconstruction costs (All Tiers).

Regulatory

Citizens and society benefit from the efficient management of disaster relief efforts (Tier 4). Moreover, Sentinel data ensures mining companies comply with regulations by providing essential impact information (Tier 3).

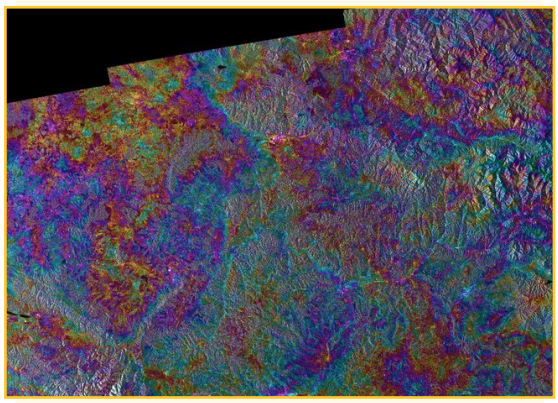
EXTENDED IMPACT

The use of Sentinel-enabled services to monitor land movement or subsidence is not only limited to monitoring the aftermath of mining operations but can also be used more generally to help both public agencies and private actors plan mitigation measures for unstable slopes that could lead to landslides in future. At Geo-Sentinel, they provide all kinds of historic and forward-looking analyses of ground deformation and slope stability monitoring services through utilising Sentinel-1's data archive. Also, given the geographic coverage of Sentinel data, they can extend their services easily to any given region across Europe and even the globe.

Local, regional, and national authorities can use Sentinel-1 InSAR to monitor the structural integrity of infrastructure, including dams, bridges, railways, and buildings. Urban planners can make data-driven decisions about ideal locations for new infrastructure projects, taking into account natural hazard risks like landslides and subsidence. These benefits apply to all InSAR-based studies, bolstered by geodetic and geophysical expertise. The authorities seek solutions to queries like where to reinforce this structure and which location suits our plan best. In conclusion, using the versatile tool that is InSAR, contributes to a safer and more informed decision-making for environmental and infrastructure management.

ABOUT THE PROJECT

The Sentinel Benefits Study (SeBS) is conducted by EARSC (European Association of Remote Sensing Companies) with partners The Greenland, IIASA (International Institute for Applied Systems Analysis) and Evenflow on behalf of the European Space Agency (ESA). It has the goal to study 20+ full cases by analysing the impact of the use of Sentinel data along a value-chain. This short case has been prepared where there has been an interesting use made of Sentinel data, but it has not (yet) been possible to conduct a full case. It tells the story of the use of Sentinel data without going deeply into the economic or environmental benefits.



"InSAR data provided a remarkable overview of a large, slowly creeping landslide occurring within the extent of residential area adjacent to a mining field, exhibiting notable spatial and temporal variations. This dataset played a pivotal role in pinpointing "hot spots" with greater deformation dynamics within the sliding mass. Subsequently, specialised subsurface monitoring techniques were deployed in these identified locations."

- Eduárd András, Geo Search

We acknowledge that the understanding of the case was supported by discussions with Péter Farkas from Geo-Sentinel and Eduárd András from Geo Search. We thank them for their valuable insights and availability.

Do you know an interesting case demonstrating the benefits derived from the use of Sentinels data?

Email info@earsc.org

More Information on Sentinels Benefits Studies:

www.earsc.org/sebs

The Sentinels Benefits Study is funded by the EU and ESA.
The views expressed in this study cannot be taken to reflect the official position of the EU or of ESA.