Rheticus®
monitoring the evolution of our Earth

Rheticus® Displacement

Satellite monitoring of land and infrastructures

Technical Specifications

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1. Rheticus®

Rheticus® is an automatic cloud-based geoinformation service platform (Figure 1), designed to deliver fresh and accurate data and information for monitoring the evolution of the Earth's surface. The platform includes services for dynamically monitoring the Earth's morphology, vegetation, infrastructure as well as coastal areas and seawater.
Rheticus® provides information by means of graphic indicators, dynamic diagrams and pre-set reports. The provided information allow customers to immediately perform assessment operations over areas of interest.
Access to Rheticus® is made available by subscription and allows users to have continually updated information.
The service update is guaranteed through the use of satellite images, mapping data and environmental information available online as open data. The service is updated with the availability of fresh incoming data, and the refresh rate can range from monthly to daily frequency depending on the service characteristics.
Rheticus® is available through the web portal on portable devices, such as tablets and smartphones. Information is displayed on a pre-set dashboard that simplifies the analysis of monitored phenomena, providing users with a comprehensive overview. Services are also available in Machine to Machine mode (M2M) via standard sharing protocols, making the platform an information hub that delivers content to other online systems. Export capabilities of data and information are also available, allowing users to download standard formats and facilitate their use in other external application environments.

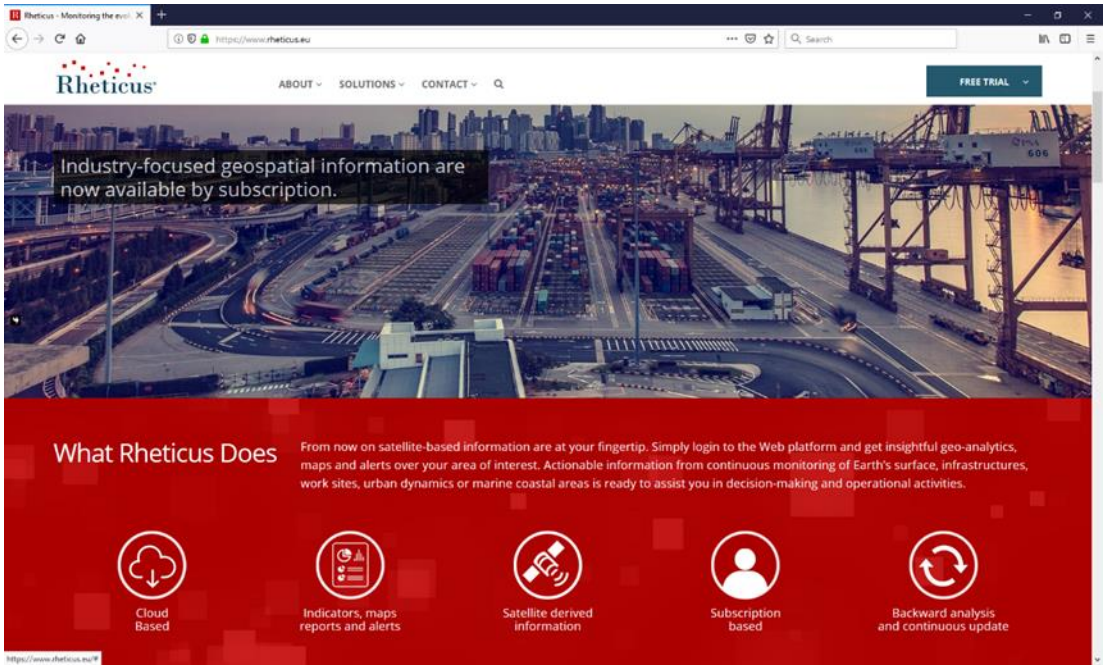


Figure 1: Rheticus® Website https://www.rheticus.eu

Rheticus® Key Features	
The service	▸ Best cost/performance ratio thanks to the use of open data, automatic processing chains, and the adoption of a cloud architecture. ▸ Geo-information services designed to meet users' needs. ▸ Services available worldwide.
Data	▸ Use of geospatial information and open data available on the cloud. ▸ Direct online access to major satellite image providers using the best data available over the areas of interest.
Processing	▸ Automatic data processing throughout the entire production chain, ensuring timely and regular updating of geo-information services. ▸ Standardised processing procedures for high quality geo-information services.
Delivery	▸ Outputs following standard specifications and quality requirements, measurable through predefined metrics. ▸ Metadata are provided with geo-information services. ▸ Information and data are provided in standard formats for use with office automation, CAD and GIS applications. ▸ Accessible from desktop PCs, tablets and smartphones through web browsers or M2M mode.
Terms & Conditions	▸ Conditions of use and license for the data, information and services offered by the platform: https://www.rheticus.eu/wp-content/uploads/2018/05/terms_and_conditions.pdf

Pick the Right Service for Your Needs	
Rheticus® DISPLACEMENT	Landslide and subsidence monitoring for land-use and infrastructure planning and management
Rheticus® NETWORK ALERT	Monitoring of water and sewer networks for the detection of potential failures linked to ground movements and displacements
Rheticus® SAFEWAY	Monitoring of transport infrastructures to better build, manage, and maintain safe and efficient structures
Rheticus® MARINE	Monitoring of coastal water and freshwater quality linked to eutrophication, and marine resource exploitation
Rheticus® AQUACULTURE	Farm monitoring and identification of best harvesting and selling times for optimizing aquaculture activities
Rheticus® URBAN DYNAMICS	Urban dynamics monitoring to identify anthropogenic changes: soil sealing, urban sprawl, illegal building, urban heat islands
Rheticus® WILDFIRES	Burnt area detection, fire severity classification, vegetation regrowth monitoring and detection of potentially illegal infrastructure activities
Rheticus® OENOVIEW	Satellite support for winegrowers and winemaking cooperatives for the optimisation of their activities, the improvement of productivity and quality

2. Rheticus® Displacement

Satellite monitoring of land and infrastructures

2.1. Overview

The monitoring of the Earth's surface and infrastructures is a key activity to ensure people's safety, environmental protection and the safeguarding of assets at all stages of the life cycle of infrastructures, from design to production, management and maintenance. The use of traditional techniques (total stations, GNSS network, etc.) for periodic monitoring of wide or remote areas requires considerable economic and time resources, moreover not feasible for small-to-medium scale. On the other hand, satellite monitoring allows to overcome these limits, reaching high frequency, precise and accurate actionable information thanks to the ever-increasing availability of open data.

Rheticus® Displacement is a turnkey cloud-based web service for the continuous monitoring of ground movements over areas affected by landslide or subsidence phenomena, and for monitoring infrastructure stability (Figure 2).

Doing so, Rheticus® Displacement indicates locations of concern and lets operators to act upon the information. Thus, the service allows an "a priori" approach, helping to highlight problems before they become critical. As a result, end-users better manage their financial resources and reduce service disruptions and/or threats for people.
All those information are updated[2] and delivered to end-users with extremely intuitive Business Intelligence tools to add dynamic analysis and new features to their planning, management and maintenance activities.

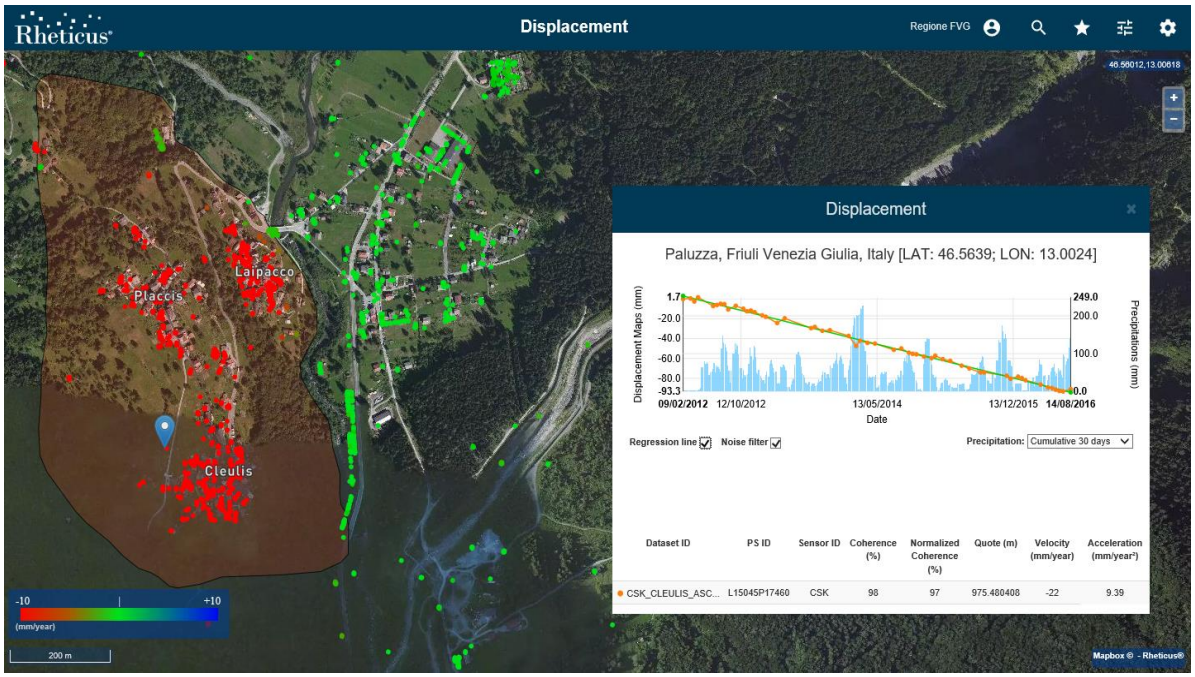


Figure 2: Rheticus® Displacement User Interface[1]. Example of urban area monitoring, trend of instabilities, rainfall data, and filtering tools.

[1] User interface is continuously enhanced to offer a better user experience and new features.

2.2. Who is it for?

Rheticus® Displacement is useful to different target users:

- Governmental authorities in charge of urban planning, land and infrastructure monitoring, civil protection in areas affected by landslide and/or subsidence phenomena;
- Companies in charge of the management and/or maintenance of transportation networks;
- Multi-utility companies, including water and sewage, energy supply, oil&gas, in charge of management and/or maintenance of pipeline networks;
- Mining companies;
- Engineering offices in charge of infrastructure planning and design;
- Engineering companies in charge of infrastructure building;
- Insurance companies.

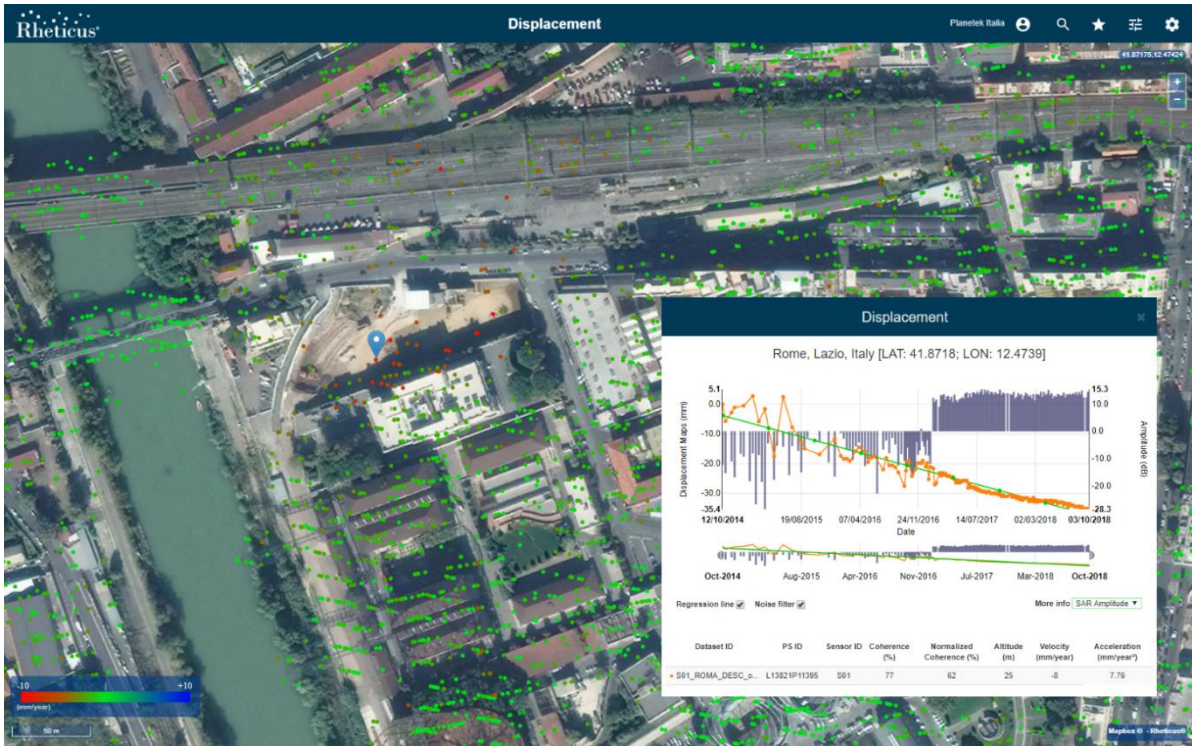


Figure 3: Monitoring over an urban area.

3. Technical Specifications

Rheticus® Displacement provides updated[2] levels of concern about ground or infrastructure movements due to landslides or subsidence phenomena, based on measurements of displacement over time.

3.1. Activation

Once the client performs the subscription to the service and provides the extent of the Area of Interest (AoI) throughout a georeferenced vector file (ESRI shapefile, KML, DWG/DXF), the service is activated over the customer's AoI.

At service activation, the client gains access to the web platform throughout the subscription duration.

The service is available at https://www.rheticus.eu/login/ with the credentials provided at activation.

3.2. Operation

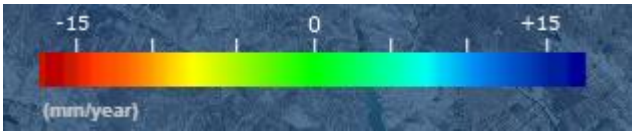
Once the client logs into the web platform and launches the web application, the map of Persistent Scatterers (PS) together with relevant analytics are loaded within a Business Intelligence (BI) dashboard. PS are highly stable points on the ground such as buildings, monuments, roadways and railways, electric towers, rocky outcrops and so forth. Displacement of PS is measured (Figure 4).

Figure 4 Monitoring of an airport area with widespread subsidence phenomena

[2] The standard service provides users with updates every 3 months. Different frequencies can be defined as an option on the basis of users' needs. Additional costs may incur.

Each PS is classified accordingly to the average velocity of displacement (mm/year) of the PS itself, measured through satellite radar data[3, 4, 5, 6], starting from the first available measurement[6].

The average velocity of PS is represented through a colour ramp, ranging from red (PS moving downwards along the satellite's LoS) to blue (PS moving upwards along the satellite's LoS), through green for stable ones.



Clicking on each PS (or group of close PS), a pop-up window (Figure 5, Figure 6) shows the following information related to the selected PS (or group of close PS):

- Time-line of displacement (mm), starting from the time of the first available measurement onwards;
- Time-line of cumulative rainfall (mm) (daily basis or over 30, 60, 90, 120 days);
- Time-line of amplitude[7] values (dB) of radar data;
- Dynamic tool for filtering data on temporal basis;
- Checkbox for noise removal and for drawing a linear regression line;
- Summary table of all provided parameters: Persistent Scatterer ID, Dataset ID, Velocity (mm/year), Acceleration (mm/year^2), Coherence and Normalised Coherence (%), Altitude (m).

[3] PS are identify and their velocity/acceleration are measured through a fully automatic Multi-Temporal SAR Interferometry (MT-InSAR) processing chain based on the extensively tested SPINUA© algorithm applied on satellite radar data. Additional information on the SPINUA© algorithm is available at the following link: https://www.rheticus.eu/wp-content/uploads/2018/12/SPINUA_a_flexible_processing_chain_for_ERSENVISAT_.pdf

[4] Coherence (%) is a parameter directly connected to Persistent Scatterers (PS) quality: the higher the coherence, the lower the uncertainty. Normalised Coherance ranging between 0 and 100% is also provided.

[5] Measurements of displacement are provided with a precision of ± 1.5 mm/year along the satellite's Line of Sight (LoS). The direction of measured displacement is defined by the satellite's LoS. Horizontal localization of PS is provided with a precision of ± 10 m. Data are supplied in geographic coordinate system.

[6] The standard service exploits satellite open data provided by the Sentinel-1 constellation of the European Copernicus programme. Additional information on the Sentinel-1 constellation are available at the following link: https://sentinel.esa.int/web/sentinel/user-guides/sentinel-1-sar/overview

[7] Amplitude measures the strength of an electromagnetic wave backscattered towards the satellite.

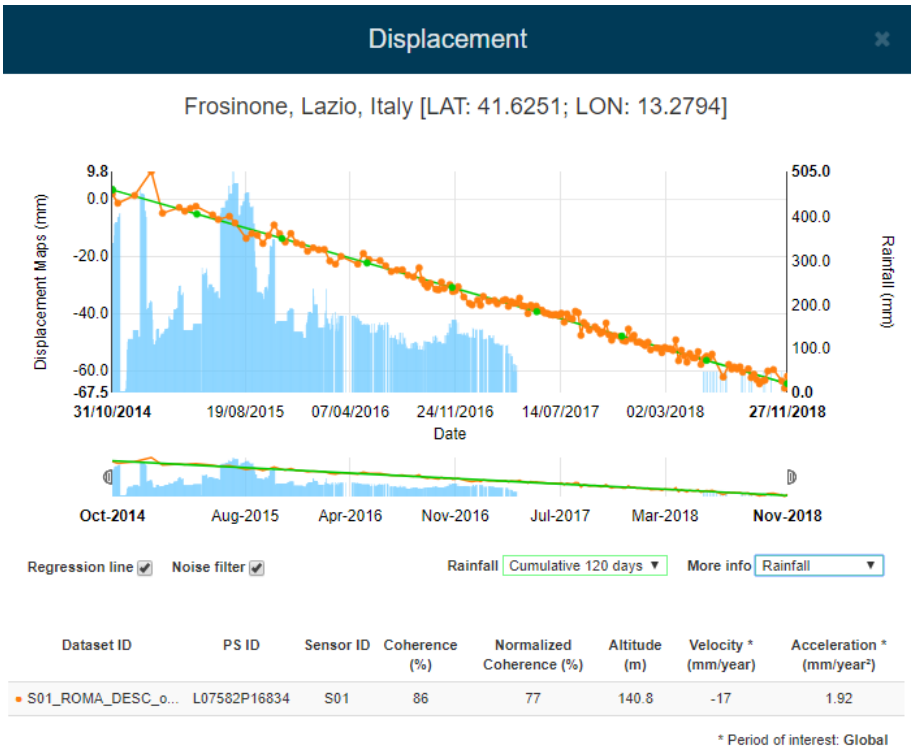


Figure 5 Measurements of PS displacement (mm) over time computed through multi-temporal satellite data, cumulative rainfall, and filtering tools.

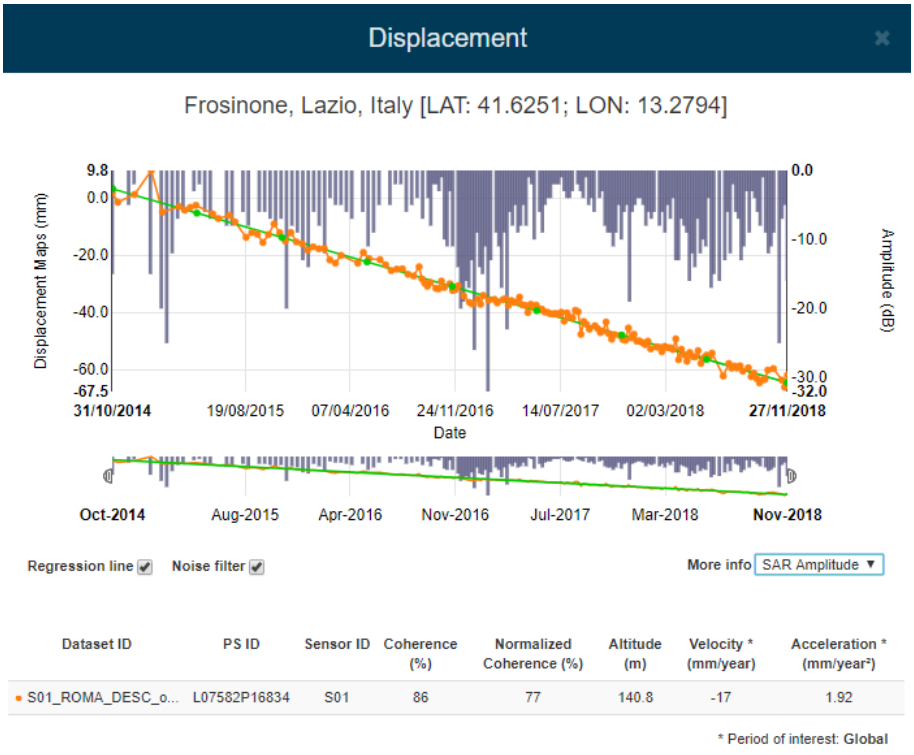


Figure 6 Measurements of PS displacement (mm) over time computed through multi-temporal satellite data, amplitude values, and filtering tools.

A right-side panel gives access to the following tools for filtering PS on the basis of:

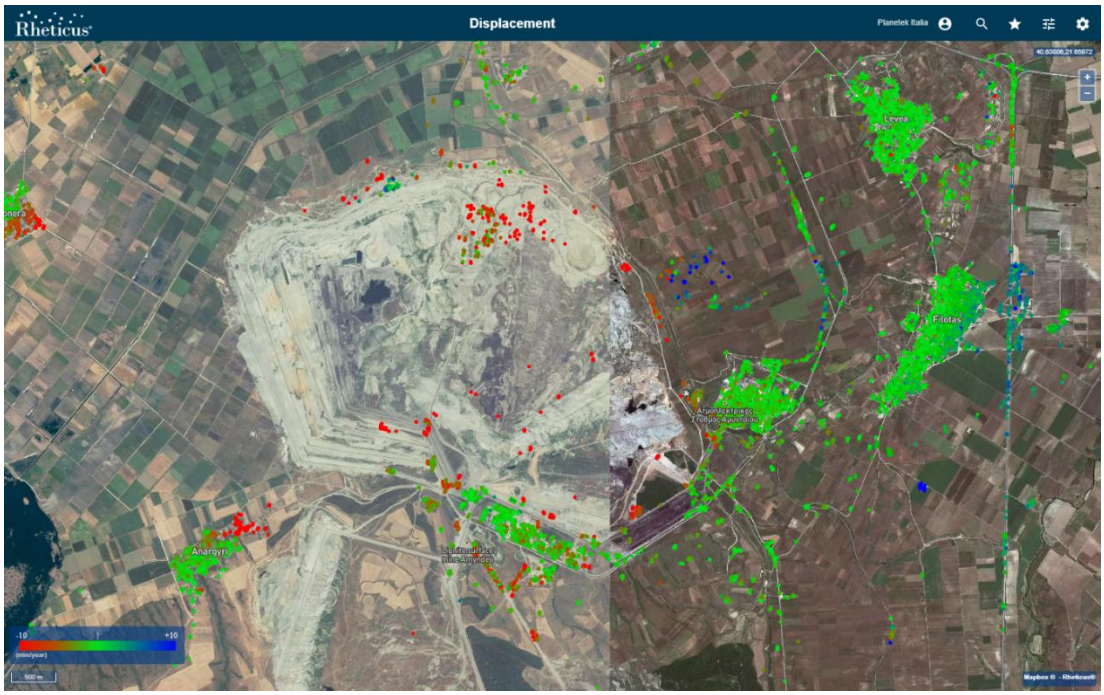
- Measurement time intervals (global or last year);
- Velocity, acceleration and/or coherence values;
- Exploited satellite data;
- Orbit travelled by the satellite (ascending or descending)[8].

Measurements are continuously updated. The standard service provides an update every three months [9]. At each update, all new acquired measurements are made available. The standard service, based on the Sentinel-1 data, provides 4-year historical measurements stating from the activation date, with at least one measurements every 12 days, and with all available measurements within 2 years backwards the activation date.

For client's specific-purposes, exploitation of different satellite data (i.e. COSMO-SkyMed, TerraSAR-X, etc.) is possible[10].

The service is accessible as cloud service and as web service following OGC standards. It is available in Machine-to-Machine mode (M2M) via standard sharing protocols.

The service is available worldwide, and is accessible via web, 24/7, with any portable device.



[8] Ascending Orbit: the satellite travels northwards, looking the target eastwards. Descending Orbit: the satellite travels southwards, looking the target westwards.
[9] Additional information on the Sentinel-1 revisit time are available at the following link: https://sentinel.esa.int/web/sentinel/user-guides/sentinel-1-sar/overview.
[10] Additional costs may incur.

4. Key Benefits

- **Regular Monitoring of Your Area of Interest**: thanks to always up-to-date satellite radar data feeding the BI capabilities.
- **Prevention of possibly structural damages**: detection of ground movements caused by subsidence and/or landslide phenomena affecting the AoI, or detection of structural defeats.
- **Innovative Analysis to Optimise Investments**: the ability to detect ground movements with millimetre accuracy greatly simplifies urban planning and infrastructure design, avoiding unstable areas, helping taking into account necessary precautions such as slope-stability intervention, predicting and minimising costs.
- **No Required Expertise with GIS or Earth Observation Data**: Complex, multi-source data is geoprocessed by the application platform, which presents you with a simple and dynamic interface to easily perform analytics and derive project-specific insight.