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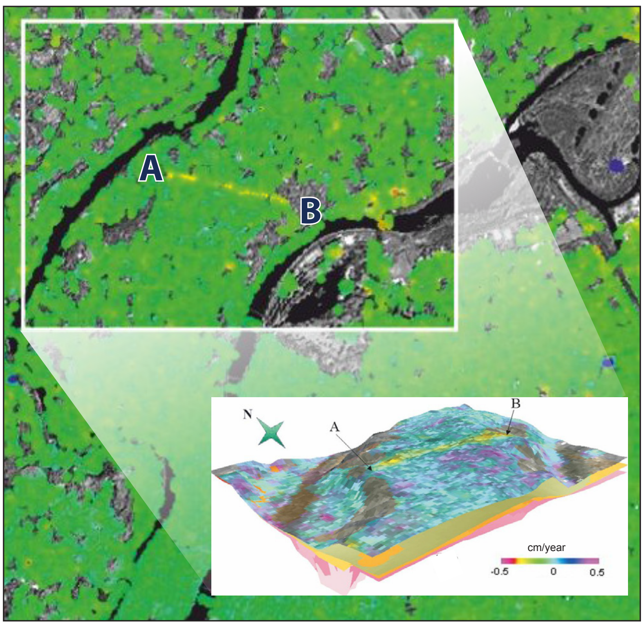
SATELLITES HELP TO MONITOR INFRASTRUCTURE STABILITY

Europe not only has a wealth of buildings, some of which have important historical value, but thrives thanks to solid infrastructure such as roads, bridges, railways and airports – all of which are essential to the economy and to our quality of life. As well as aging due to e.g. wear and tear from the weather or increasing volumes of traffic, these structures can also be subject to subsidence. As the trend towards urbanisation continues to rise, with growing pressure in both vertical and horizontal domains, ground stability becomes an increasing concern. Effective monitoring strategies are needed to identify structural problems before they become critical and endanger public safety.

Satellites can detect millimetre scale deformations and provide a synoptic view of terrain and infrastructure stability.

Satellite radar imagery is an effective tool to detect changes in the Earth´s surface over very large regions. One single satellite image can cover areas up to 10 000 km^2. Deformations of the ground owing to subsidence as little as a few millimetres can be detected using the Interferometric Synthetic Aperture Radar (InSAR) technique. This technique involves having multiple images over the same region that have been acquired over time. The images are combined to detect slight changes that may have occurred between acquisitions. Precise synoptic measurements of infrastructure deformations can also be obtained with a technique that makes use of ground reflectors called "persistent scatterers", which have stable reflecting patterns in the satellite radar signals. They typically correspond to man-made structures such as buildings, bridges, dams, water-pipelines or antennae, but there may be also stable natural reflectors such as exposed rocks.



The image shows the average ground surface annual velocity for the city of Lyon (France) as obtained by using the persistent scatterers interferometry (PSI) technique (based on Envisat radar data between 1992 and 1999). The green areas indicate terrain stability, whereas shades of red indicate subsidence and blue shows areas of uplift. The linear deformation pattern (yellow line between A and B) highlights subsidence of more than 2,5 mm per year which was attributed to underground motorway works. The small image shows the corresponding 3-dimensional model that was built from the same data. This kind of deformation maps have great potential in highlighting areas of infrastructure where particular attention or works should be directed.

Source: Terrafirma; PSI processing: Altamira Information; Geological interpretation: BRGM.

Facts

- Subsidence can be caused by different factors, both natural (e.g. tectonics, soil compaction etc.) and anthropogenic (e.g. mining, underground water or gas abstraction, tunneling works etc.)
- Individual buildings, railways, bridges, roads and other strategic civil assets (e.g. power plants) can be subject to ground surface displacements which may cause structural damages
- In some European regions property damage claims related to subsidence are estimated to rise by 50% in the period 2021 to 2040
- Coastal lowland areas are particularly vulnerable to flood risks, e.g. when subsidence is coupled with sea level rise and extreme weather events

Benefits

Satellites help civil authorities, allowing:

- detailed monitoring of the effects of subsidence over very large areas
- identification of unstable areas to support planning of new infrastructure or renovation projects
- efficient monitoring of infrastructure stability, guiding focused surveys in the event of risk

Policy Objectives

- EU Soil Thematic Strategy
- Convention on Environmental Impact Assessment (EIA) in a Transboundary Context
- Eurocode 8
- EU Floods Directive

Copernicus services

Currently, no Copernicus service supports this application.

Sentinel contribution

Copernicus will provide improved SAR data for stability monitoring with Sentinel-1 assuring:

> continuous, all-weather day and night imagery

> rapid revisit period in the same imaging mode (6 days)

> constant and regular acquisition to build a large global archive

> wide area coverage, thanks to the 250 km image swath width

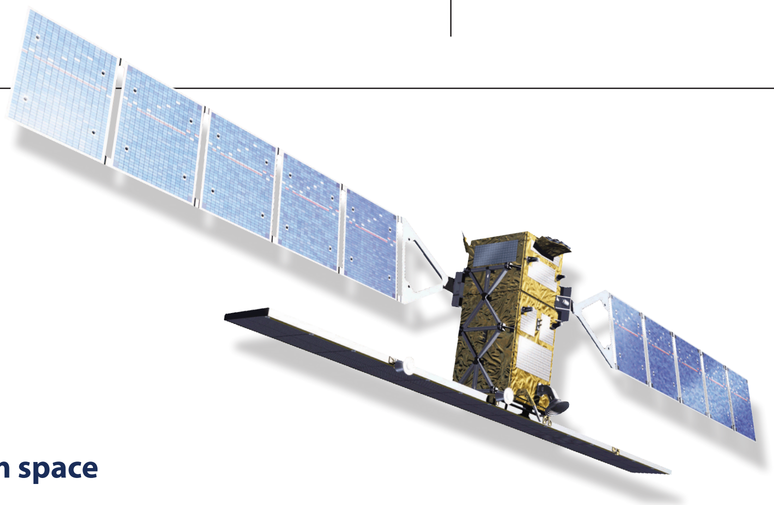
Next steps

> Ensure continuous SAR image acquisitions over the main civil assets

> Expand processing capabilities by devloping cost effective, automated methods for wide area mapping using PSI

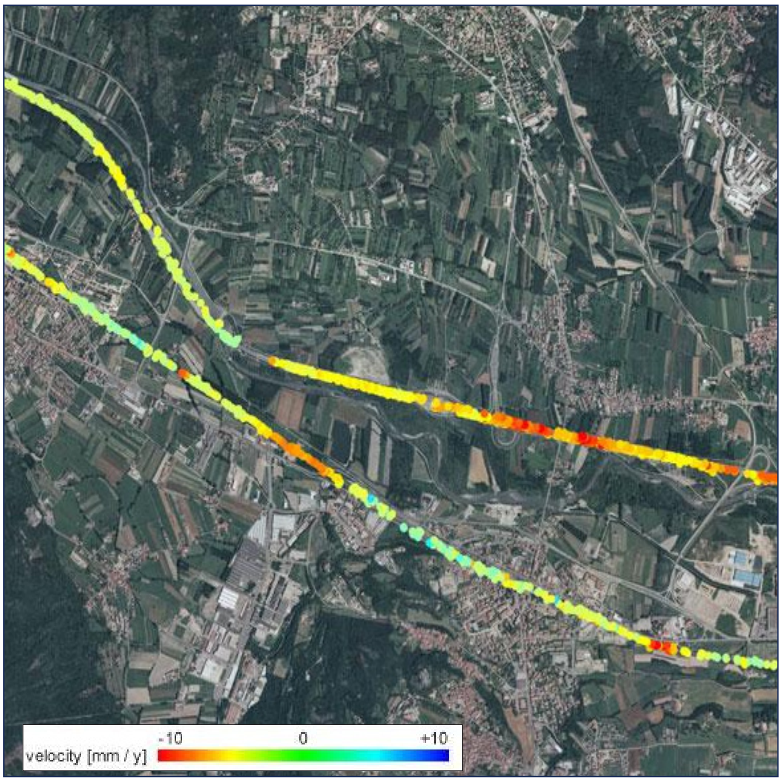
> Enhance European cooperation on satellite based terrain deformation mapping

> Integrate Earth observation and in-situ products in operational activities for subsidence risk management, e.g. with GPS to calibrate wide area deformation measurements to support seismic hazard analysis



Sentinel-1

Detecting slight surface changes from space



Radar satellites play a major role in detecting subsidence of only millimetres over large areas. The combination of multiple images of the same area acquired with radars such as the SAR that was carried on Envisat show any slight change that may have occurred between acquisitions.

The Sentinel-1 satellite, due to be ready for launch in 2014, will ensure the continuity of SAR data for years to come, with improved coverage compared to its ERS and Envisat predecessors. The mission, with constant and regular acquisition mode will overcome the limitations of former similar missions and allow for a large archive worldwide to be built.

A twin satellite, expected to be launched soon after the first Sentinel-1, will complete the constellation to satisfy Copernicus coverage requirements..

The image shows ground displacements detected with RADARSAT-1 data along a motorway in Italy between 2003 and 2010. Red and yellow areas show subsidence, while blue areas show uplift. RADARSAT is a Copernicus contributing mission similar to Sentinel-1.

Source: Tele-Rilevamento Europa (TRE); Background image: Microsoft Virtual Earth