Fall and Rize

Cristian Rossi looks at a collaborative UK-Turkey satellite imaging project that Is helping authorities plan a radical solution to subsidence problems afflicting the city of Rize

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Since 2014, Sentinel-1 Synthetic Aperture Radar (SAR) data has been freely available through the European Copernicus programme. This data has been a game changer for the Earth Observation (EO) community due to its accessibility and availability in all parts of the world with a guaranteed repeat acquisition frequency of 6 to 12 days since 2016.

Although SAR imagery is generally difficult to interpret for non-specialists, it enables specific applications that profit of the independence of solar illumination and weather, such as the monitoring of forest, crops and cryosphere, and the very specific radar use in surface displacement estimation. The latter requires a consistent temporal stack of data and the Sentinel-1 mission is providing just that.

A major feature of this application is the estimation accuracy, in the order of millimetres. This is particularly impressive when thinking that these images are taken from space, with sensors at distances from Earth in excess of 500 kilometres. A limitation of this free source of imagery is the spatial resolution of about 10 meters which prevents very fine measurement grids. Nevertheless, the local estimation of terrain subsidence or uplifts may be employed in urban studies, for instance in estimating the structural health of infrastructures.

Collaborative work

Within this context, a cooperation between the Open University (UK), the Istanbul Technical University (Turkey), and the Satellite Applications Catapult (UK) led to a recent publication[1] that will be discussed at the ESA's Living Planet Symposium to be held in Milan in mid-May.

The study focuses on Rize, a city of about 100,000 inhabitants on the Black Sea coast in north-east of Turkey and which has been reported to be at high risk of collapse. For this reason, the local municipality and the government are planning radical solutions such as the relocation of the entire town centre to another location.

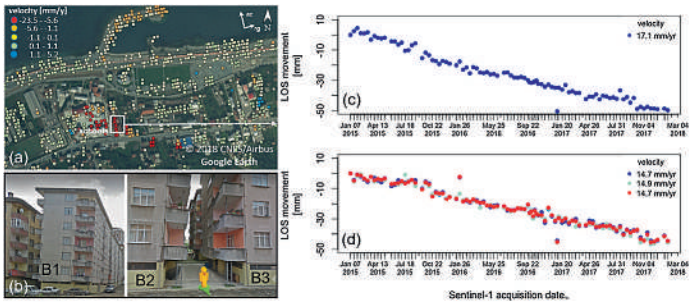
Subsidence is occurring as the city centre has been built on artificial ground reclaimed from the sea in the 1960s. Since then, many multi-floor buildings have been constructed despite official plans that recommended a maximum of three floors per building. Moreover, the foundations of many buildings, below water level, are reported to be damaged.

Useful findings

Many findings are reported. For example, Sentinel-1 has been shown to be an effective tool for monitoring, predicting and mitigating toe scour at seawalls.

The city of Rize has been declared at high risk of collapse and radical solutions such as relocating the entire city centre are being considered. Photo: Valery Shanin / Shutterstock

Average ground deformation map across Rize derived from 92 Sentinel-1 images. Red and blue points correspond to the velocity away and towards from the Sentinel-1 satellites, respectively.



Sentinel-1 ground motion measurements over the Google Earth image of Engindere district of Rize (a), with Google Maps Street Views (b) acquired in June, 2015, highlighting the subsidence in Deniz housing estate, which is marked with the white box in the first subfigure and its corresponding displacement time series (c,d).

Moreover, assets over the reclaimed area also face subsidence problems. While the rehabilitation process has been substantially performed by the municipality in 2015, subsidence still exists on the site and movements detected could indicate a sign of cracking on the foundation of buildings, probably going below water level.

A further example focuses on the residential area with the highest collapse risk in Rize. Although local photographs were highlighting the deformation in the district, the study allows a reconstruction of the deformation pattern in the areas without in-situ geodetic measurements. Such specific information is essential for local authorities and for warning local communities about the structural health of their houses.

This work contributes to an understanding of the risks posed by reclamation process in Rize since the 1960s. It helps to quantify the subsidence rate in the city and opens a discussion on how to monitor large-scale construction projects such as Rize-Artvin airport, for which a proper planning of the reclamation process (e.g. the location, the rock type, type of monitoring, etc.) is key to the success of this mega project.

Reference

1 E. Erten, C. Rossi; The worsening impacts of land reclamation assessed with Sentinel-1: The Rize (Turkey) test case; International Journal of Applied Earth Observation and Geoinformation; 74, Feb. 2019, pp. 57-64