BENCHMARK OF C-BAND RADAR CORNER REFLECTORS BASED ON SENTINEL-1 SAR IMAGES. FIRST RESULTS IN THE MONITORING OF THE DUNASZEKCSÓ LANDSLIDE (HUNGARY) USING CORNER REFLECTORS.

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Abstract

Synthetic Aperture Radar (SAR)-based interferometry (InSAR) is a technique widely used for the detection and monitoring of the deformation of different surfaces that reflect the electromagnetic (EM) wave emitted by the SAR sensor. SAR imaging is a coherent technique, meaning that not only the amplitude but the phase of the reflected EM wave is captured by the antenna. Calculation of surface displacement is possible from the phase differences produced by subtracting the phase values of one SAR scene from another SAR scene.

Deformations of the Earth’s surface caused by volcanoes, earthquakes, landslides and other surface processes are studied by the geoscientists using a single interferogram created from a SAR image pair acquired by spaceborne sensors. Time-series analysis of multiple interferograms made the assessment of slow, long-term deformation possible, however displacement time-series derived from the time-series analysis, are only reliable when there are sufficient number of pixels that provide stable phase values over a long period of time. In areas where there are not enough stable pixels, interferometric processing becomes challenging if not impossible. In such areas, artificial scattering objects, so-called corner reflectors, can be installed that provide stable phase values for deformation monitoring purposes.

In the framework of an ESA PIECS project (project ID: 40001186650/11/LN/SC) the Department of Broadband Telecommunications and Electromagnetic Theory of the Budapest University of Technology and Economics in cooperation with the MTA CSFK Geodetic and Geophysical Institute, developed a twin corner reflector based on the sensor characteristics of the Sentinel-1 satellites, capable of providing stable phase information for geodynamic investigations. The reflector geometry and dimensions were optimized for deformation monitoring using numerical and analogue modeling. Several reflector networks were deployed in Hungary. Three monitoring networks are located in areas susceptible to landslide activity: Fonyód (landslide area at Lake Balaton), Dunaszékcső and Kulcs (landslides near the banks of the Danube). Another testing network is installed in Sopron, a non-deforming area.

In this contribution we present the first deformation time-series of one test network in Dunaszékcső, Hungary. To capture the high gradient of the deformation and avoid the undersampling of the signals, both Sentinel-1A and B SAR scenes were processed. Altogether 72 scenes were processed with the GAMMA software. The phase of the reflectors was extracted from the SLC scenes, referenced to a nearby reflector and unwrapped. A rapid subsidence signal of about 4.8 mm / 12 days was revealed to the north-east of the IB1 reference reflector in the stable area, and a slower ± 2 mm / 12 days signal to the south of the reflector IB3 in a moving area, suggesting that landslide is still ongoing and the area has not yet stabilized. Line-of-sight deformation was compared to campaign GNSS measurements. The results show that the subsidence rates derived from measurement techniques, i.e. GNSS and InSAR, are in the agreement within the error bounds.

Geological background

- banks along the Danube river – susceptible to landsliding
- hydrological forcing – periodic variation of Danube river water level – landslide [1]
- 2007 Dunaszékcső, 72 m rupture, sliding mass: 0.3 x 10^9 m^3 [2]
- Vár Hill test area mainly composed of loess

Reflectors in the landslide area

Figure 1: Schematic cross-section of the landslide at Vár Hill, Dunaszékcső. Figure from [1], based on [1]. GWL = Ground Water Level; HW = Highest Water; LW = Lowest Water

Figure 2: Reflector IB2 with rod and GNSS antenna (A); rod and antenna are only present during GNSS observations

Figure 3: Reflector IB4 with the landslide area (B)

Figure 4: Spatial distribution of reflectors with the landslide area outlined (C); from Google Maps

Figure 5: Calculated LOS deformation from reflectors

LOS Deformations

Table of fitted linear displacement velocity values and the RMSE of the fit:

<table>
<thead>
<tr>
<th>Reflectors</th>
<th>LOS velocity (mm/12 days)</th>
<th>RMSE (mm/12 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IB3</td>
<td>1.491</td>
<td>0.931</td>
</tr>
<tr>
<td>IB4</td>
<td>-1.991</td>
<td>2.086</td>
</tr>
</tbody>
</table>

Discussion

- reflectors are capable of determining velocity trend – promising results
- We do not yet know what causes the divergence between measured GNSS and InSAR LOS deformation time-series in the case of IB3 - (multiple phase jumps?)
- In the future the emphasis will be on investigating the discrepancy between GNSS and InSAR measurements at reflector IB3

References


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