Monitoring of terrain deformation and sinkhole hazard with Corner Reflector SAR Interferometry

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In western Poland, the town of Wapno has experienced dangerous land deformation due to a salt mine collapse in 1977. The town center has faced ongoing subsidence, with rates reaching up to 5 mm/year. The most significant risks stem from unstable geological conditions, causing periodic sinkholes, faults, and cracks in the terrain. After the mine's closure, no organization was responsible for monitoring deformation until the Geohazards Center of PGI-NRI was enlisted in 2013 to create an affordable remote sensing system.

Using PSI processing of archived ERS and Envisat data, radar corner reflectors (CR) were deployed at seven locations for SAR (Synthetic Aperture Radar) interferometric measurements, where natural radar reflecting objects were lacking. These specially designed corner reflectors enabled ascending and descending TerraSAR-X and Sentinel-1 observations, as well as GNSS and optical leveling measurements for validation. From 2014 to 2015, 40 TSX acquisitions were completed, followed by continuous S1 data.

In March 2021, a sinkhole emerged in one problematic location, prompting monitoring via terrestrial laser scanning and UAV photogrammetry. By carefully processing and decomposing Line of Sight data from all available TSX and Sentinel-1 A satellite tracks, near-daily CR displacement records were reconstructed and validated with leveling and GNSS. The CR displacement data verified the subsidence velocity obtained through PSI processing. The long-term CRInSAR observations (nearly 8 years) also identified seasonal effects and subsidence anomalies linked to sinkhole development.

Corner reflectors have proven crucial for detailed scientific monitoring and sinkhole hazard mitigation. In 2022, the monitoring system was expanded with four additional corner reflectors to address spatial gaps in problematic areas.

08.2022 new CR's deployment (S1 ready)

• 2657

Sinkhole 2021





2.0 -1.5 1.0



Sinkhole 2021

08.2015

26.03.2021

sinkhole

RECENT S1 PSI + CRInSAR

08.2015 09.2016 TSX CRInSAR

09.07.2015 CR deployment (TSX ready)

> 16.04.2007 sinkhole





Sinkholes in former gypsium mine



sinkhole 2007



sinkhole 1977





15.08.1977 sinkhole

05.08.1977 MINE **COLLAPSE**

1917

1828

Gypsium mine



Damages to the buildings, cracks and sinholes associated with 1977 catastrophy







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