Preliminary subsidence study for the Upper Silesian Coal Basin, Poland, based on Interferometry SAR and geophysical investigations (EPOS-PL project)

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European Geosciences Union General Assembly 2018

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1. Introduction

The area of the Upper Silesian Coal Basin in Southern Poland is one of the largest coal deposits in Europe (46.9 billion tones) and it has been highly exploited in the last 200 years. The intensive extraction of the coal affects the Earth's surface stability and leads to significant terrain subsidence, often reaching 1 meter into the contour of mining panel.

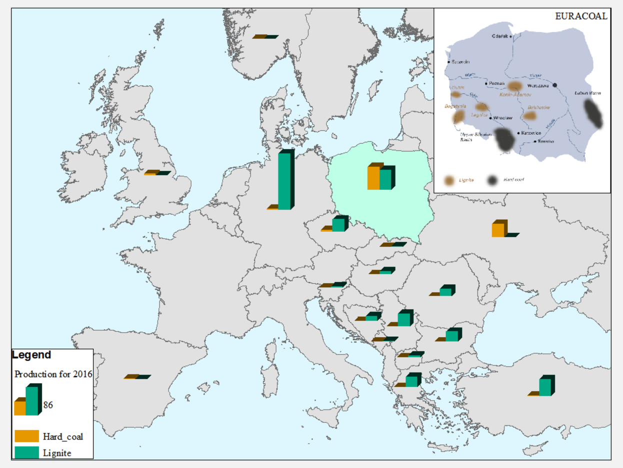


Fig. 1. Coal production in Europe for 2016 according to EURACOAL

According to the exploitation scenario the expected terrain subsidence depends on the thickness of the particular coal layer, geological conditions and old mining operations. This study presents the verification of the interferometry SAR calculated mining by the results of geodetic surveying as well as the fit of the location of subsidence spots with location of the contour of extracted coal panels.

2. EPOS-PL project

The main task of the project is the creation of a multilayer, multidisciplinary and interoperable research infrastructure, where data from different measurement networks and technique will be collected, processed, standardized and integrated in uniformed database, which will be available for analyses, applications and dedicated visualizations. For this purpose research polygons called MUSE (Multidisciplinary Upper Silesian Episode) are build in mining and post-mining areas in the Upper Silesian Coal Basin in order to integrate various geodetic measuring techniques as well as seismological, gravimetric and geophysical measurements for observing physical phenomena occurring within rock mass and subsurface zone.

Within the framework of Workpackage 9 monitoring of the mining and postmining areas by different remote sensing techniques is set. Here we present the first results from InSAR monitoring of MUSE.

3. Wirek-II

We used the available data from six cycles of levelling measurements conducted in 2017 for the area of Wirek-II coal mine in order to validate the results from the corresponding time span acquired by descending Sentinel-1 DInSAR results. The 6-days revisiting radar data are processed in standard DInSAR procedure using ESA's SNAP toolbox. The subsidence of 20 benchmarks (№ 1261÷1280) placed along the main road of Wirek (Fig. 2) is displayed in Fig. 3a (from levelling) and Fig. 3b (from DInSAR). In the northern part of the section very good concordance is observed (Fig. 4a), while at the southern part of the levelling line there is mismatch between the results from two sources. Nevertheless the radar data show stable trend with relatively satisfying quality of the coherence. (Fig. 4b).

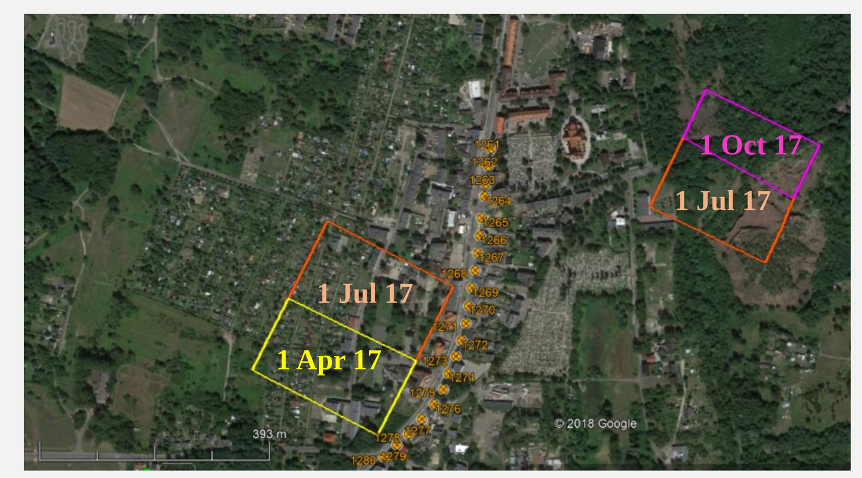


Fig. 2. View of Wirek-II area with levelling benchmarks and polygons of coal extraction

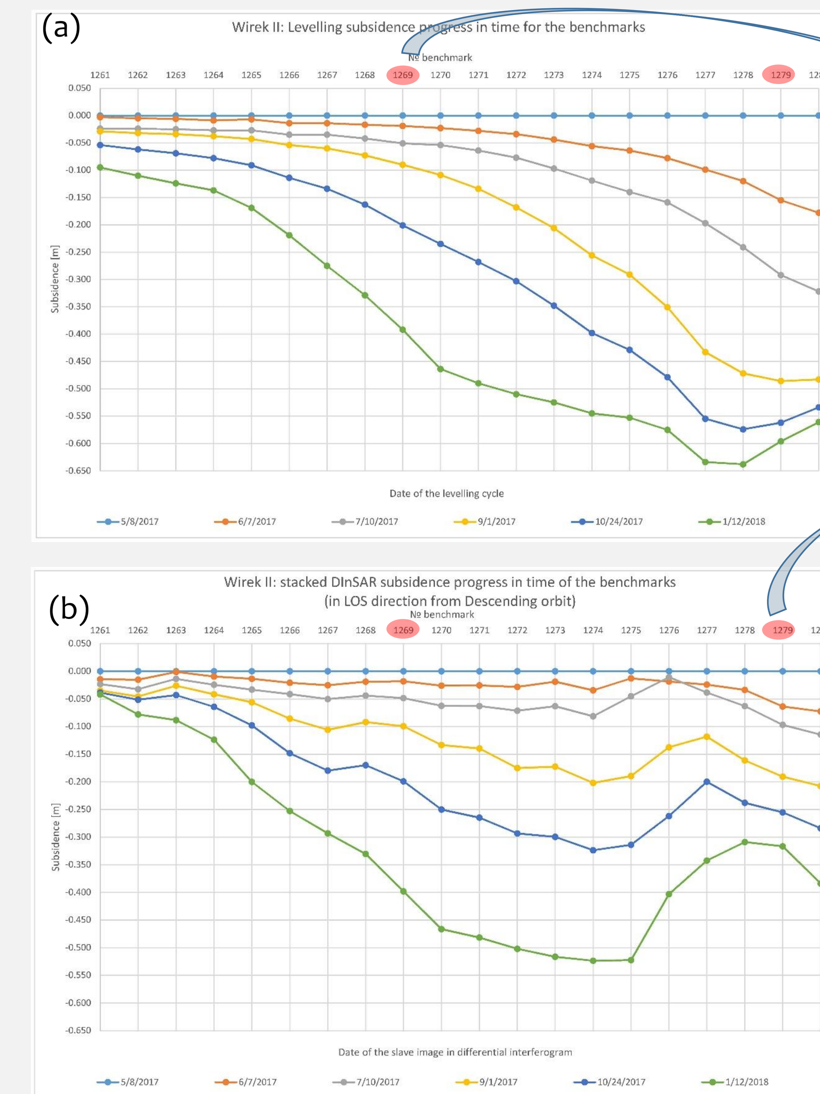


Fig. 3. Subsidence in time along the levelling line presented in levelling time cycles – (a) levelling, (b) stacked DInSAR (in Linh-of-sight direction

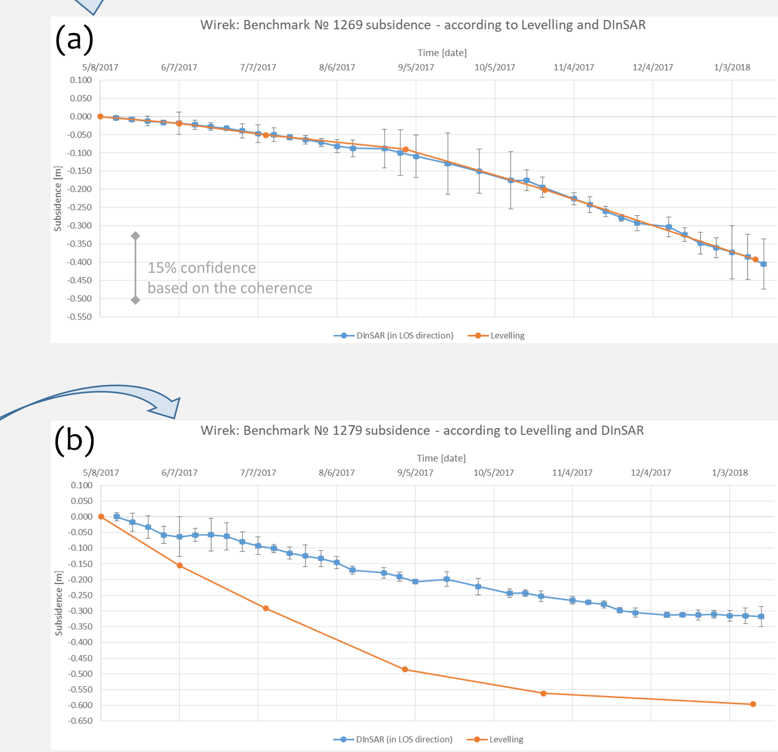


Fig. 4. Time series for selected points from the northern (a) - № 1269, and southern section (b) - №1279, of the levelling line. Orange represent the levelling data and blue – DInSAR. The bars represents the level of confidence based on the coherence value from the interferogram.

The subsiding cycle related to the mining activity is clearly revealed in Fig. 5 by the comparison between stacked DinSAR interferograms in trimesters and the areas of actual mine extractions shown in the figure with the starting date. The main ground surface deformations are compatible with the subsidence after the end of the works in the corresponding working polygon.

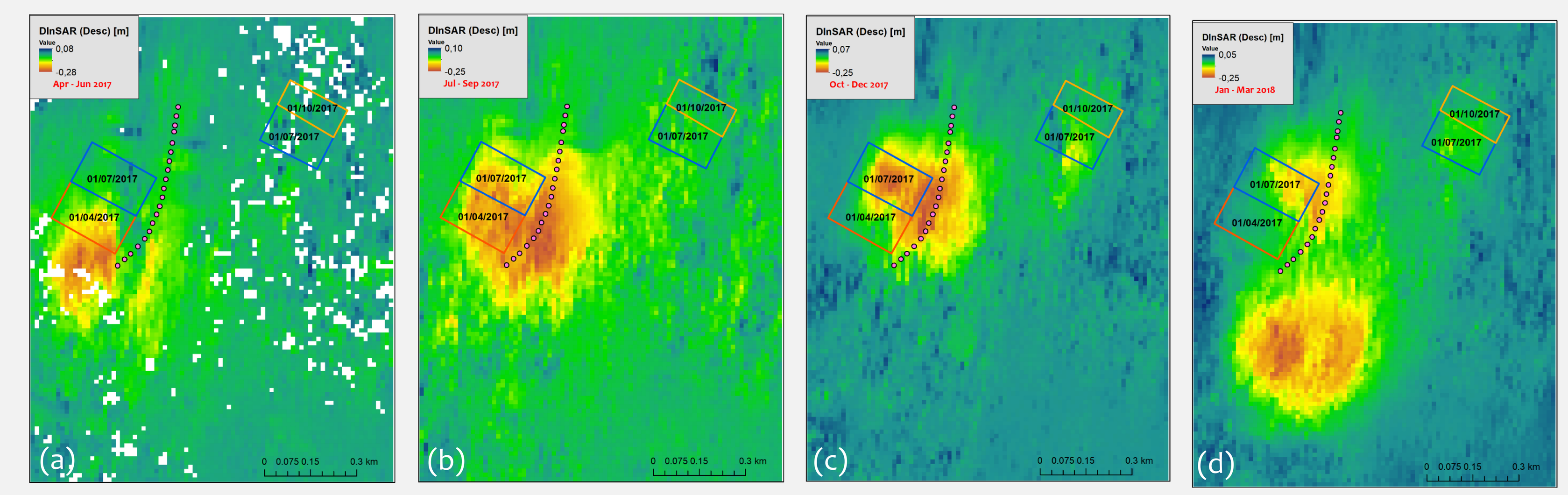
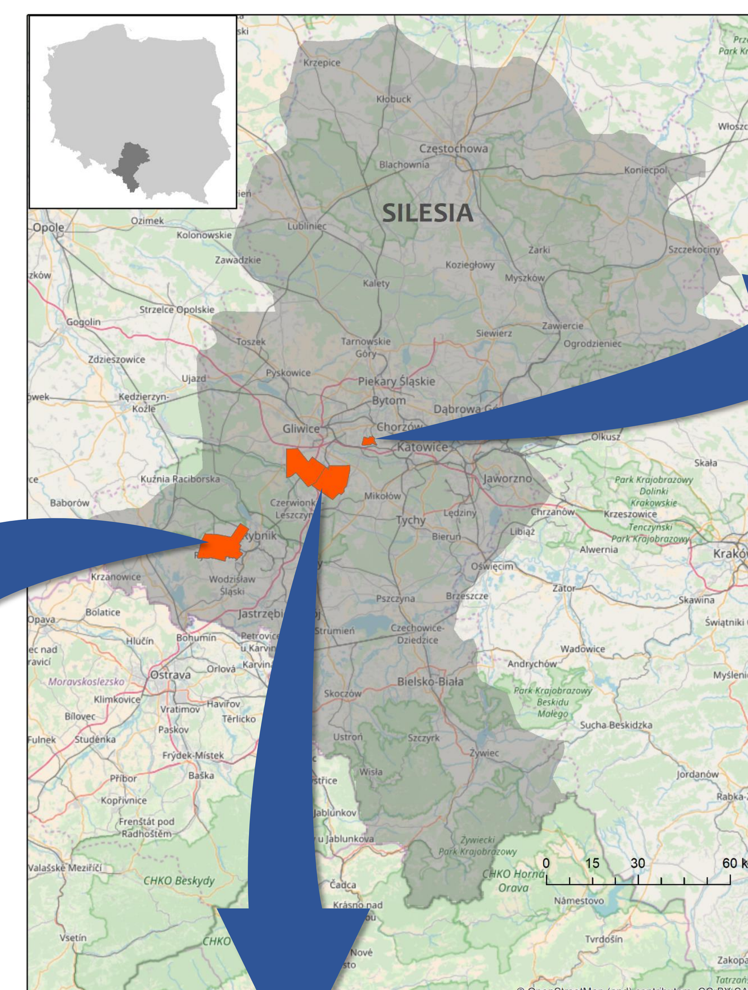


Fig. 5. Comparison by trimesters between the polygons of coal extraction and stacked DInSAR – (a) Apr-Jun 17, (b) Jul-Sep 17, (c) Oct-Dec 17, (d) Jan-Mar 18



4. Rydultowy-I

For the area of Rydultowy-I we performed two techniques – PS, conducted with SARscape software and DInSAR, with ESA's SNAP toolbox.

For the PS analyses Sentinel-1 data set for the whole year 2017 is used while the DInSAR data comprise the period of four trimesters from April 2017 to March 2018.

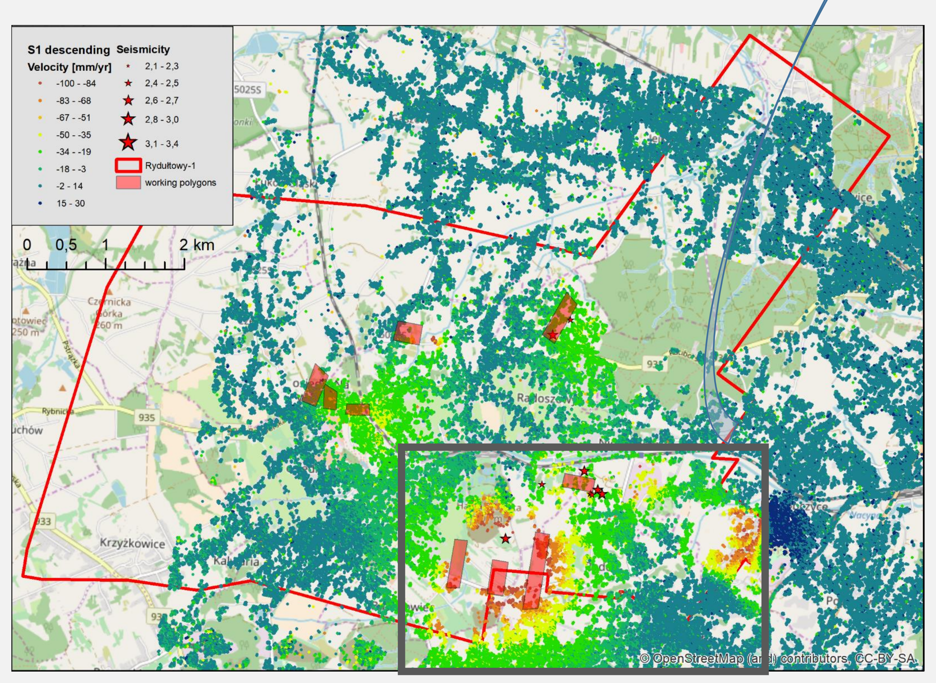


Fig. 6. PS-detected subsidence from Sentinel-1 descending data for 2017

The results from both techniques are complementing each other since the PS reveals the long-term slow surface deformation in the mining area (Fig.6) while with the results from DInSAR more detailed investigation of the coal extraction dynamics in the zones of fast subsidence can be monitored.

In Fig.7 the subsidence detected by conventional SAR for 4 trimesters shows the faster surface deformation in the hotspots of active mining works. The quality threshold is set to 0.3 of the interferometric coherence.

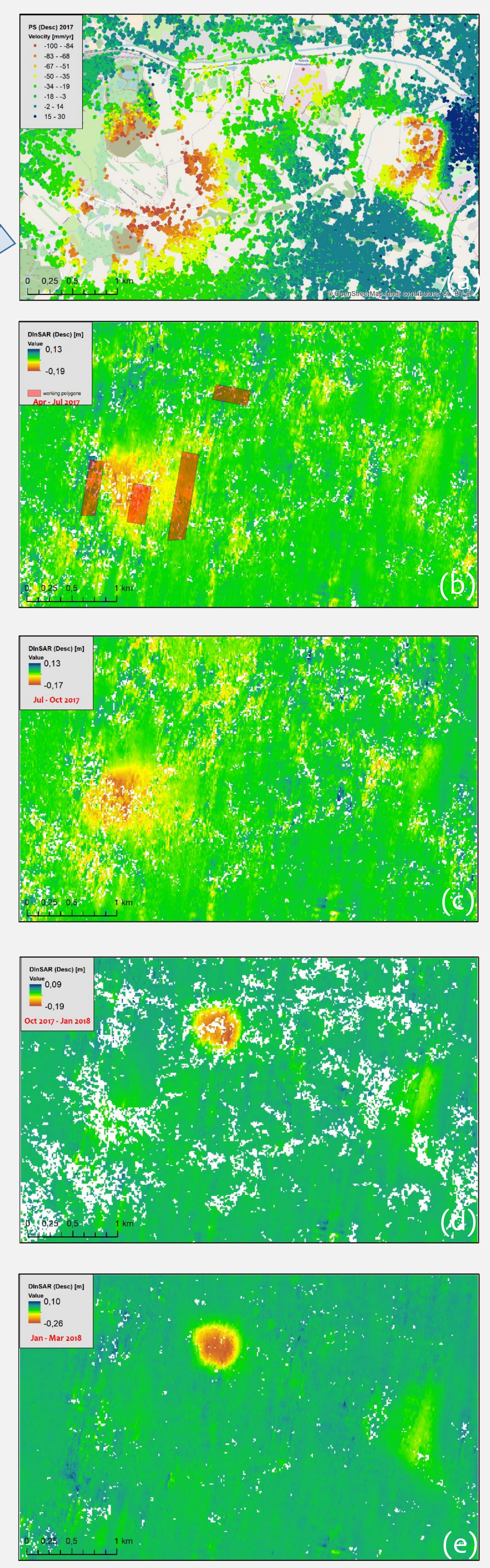


Fig.7. DInSAR-detected subsidence by trimesters

5. Knurow and Ornontowice-I

The described approaches will be applied for other mining areas like Knurow and Ornontowice-I (Fig.8) where some of the highest values of deformation are observed. Special attention will be put also on the potential deformation in the urban areas and the infrastructure like in this case the A1 highway.

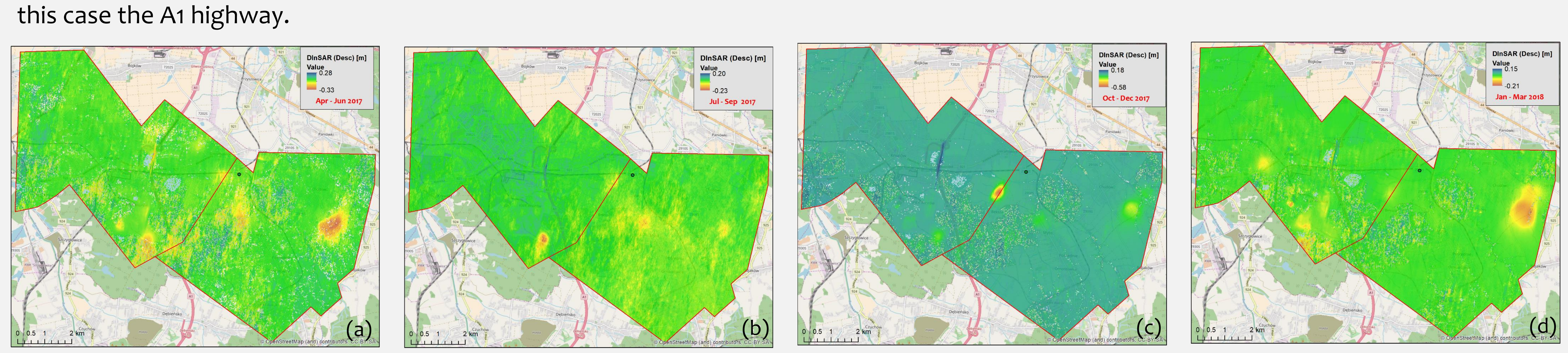


Fig.8. DInSAR-detected subsidence by trimesters

6. Future activities

The next step of realization of the tasks in WP9 of EPOS-PL project will be the installation of corner reflectors (Fig.9) in the area of mine Rydultowy-I in order to detect initial deformations and to support the 3D decomposition of displacements. Moreover, to perform monitoring of high amplitude deformations in the mining areas UAV laser scanning (Fig. 10) will be utilized.

Fig.9. A Corner reflector used in MUSE polygons

Fig.10. Laser scanning in Rydultowy-I

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