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Determination of vertical and horizontal displacements of mining areas using the DInSAR and SBAS methods

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Study Area

The Bogdanka Coal Mine, located in South-East Poland, is a hard coal mine operating continuously since 1982. Its mining area is divided into three main operating grounds, working at a depth of around 800 metres. Rapid extraction of coal with longwall mining system underground causes the ground surface to undergo displacements in form of subsidence troughs. Movements inside the subsidence trough consist of vertical subsidence, as well as horizontal shifts of ground affected by the subsidence.

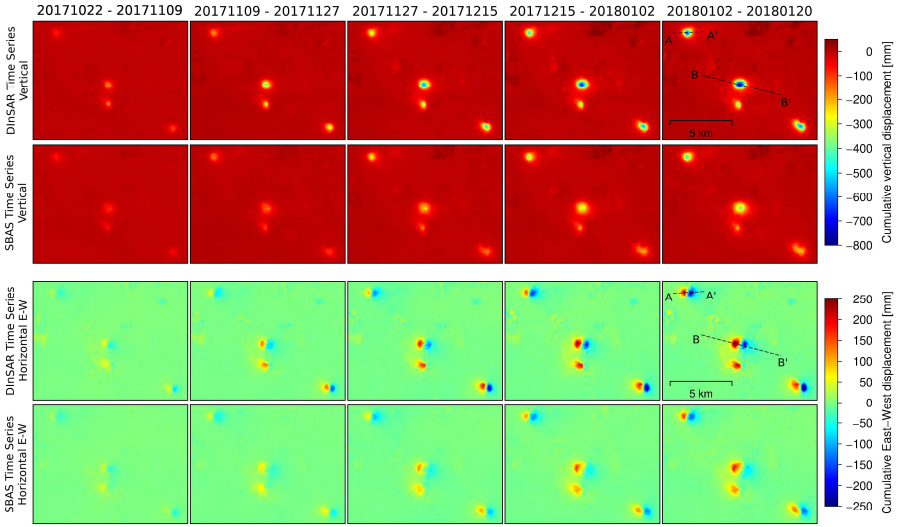

Fig. 2.: Time series of displacements derived using multiple-geometry Sentinel-1 geometry. Images in the upper part denote the vertical component of displacement calculated from DInSAR and SBAS results, respectively. Images in the bottom part represent a horizontal component of displacement in the East-West direction.

Results

Three main areas of subsidence were detected from the analysis of interferometric data. After decomposing the LOS displacements into vertical and E-W displacement components, it can be seen that both vertical and horizontal movements of ground surface occur inside the subsidence troughs.

When comparing the SBAS results with time-series created using DInSAR, a clear difference of displacement values is noticeable for both displacement components, more so in the case of subsidence. Rapid subsidence of ground surface might cause the SBAS technique to be incapable of measuring the whole value of displacement, being that it is designed to detect rather slow ground movements, while the DInSAR technique is able to identify geophysical phenomena of larger magnitude completely.

GACOS correction proved to be valuable in estimating the tropospheric delay in interferograms, allowing for clearing of the atmospheric signal from interferograms affected the most, resulting in clearer results of displacement after the LOS decomposition, especially the E-W component.

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Method

Small Baseline Subset Time Series (SBAS), as well as Differential SAR Interferometry (DInSAR) techniques were used to calculate the LOS displacement values for a period of 3 months (October 2017 – January 2018). The two techniques were both used to estimate the time-series of displacements separately, in order to compare the suitability of each technique to estimate ground displacements over mining areas. Additionally, the Generic Atmospheric Correction Online Service for InSAR (GACOS) data were used to mitigate the tropospheric delays present on the interferograms.

In order to derive the vertical and horizontal components of displacement over the study area, a multi-geometry methodology was applied. Line-of-sight (LOS) displacements from both ascending and descending Sentinel-1 tracks, together with the acquisition geometry data (heading and incidence angle) were used to resolve the vertical and horizontal (in the East-West direction) components of displacement over the AOI.

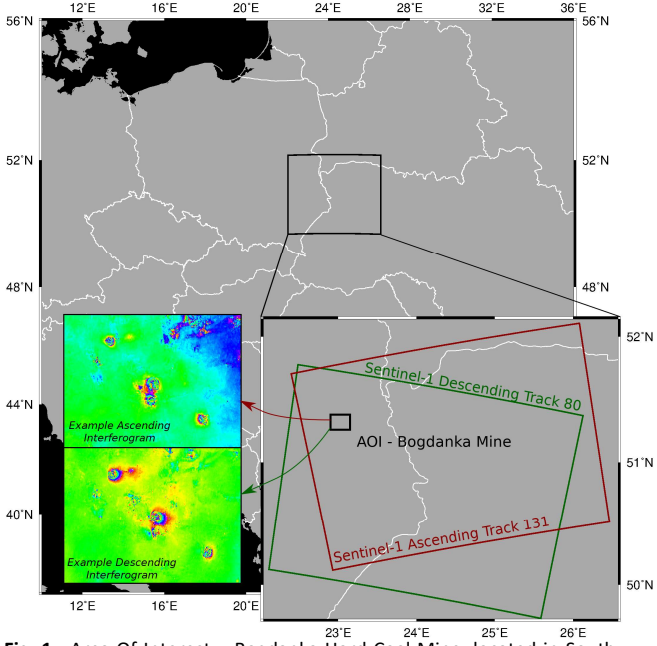

Fig. 1.: Area Of Interest – Bogdanka Hard Coal Mine, located in South-East Poland. Bottom-right part: Sentinel-1 imagery over AOI. Bottom-left: example interferograms over the study area.

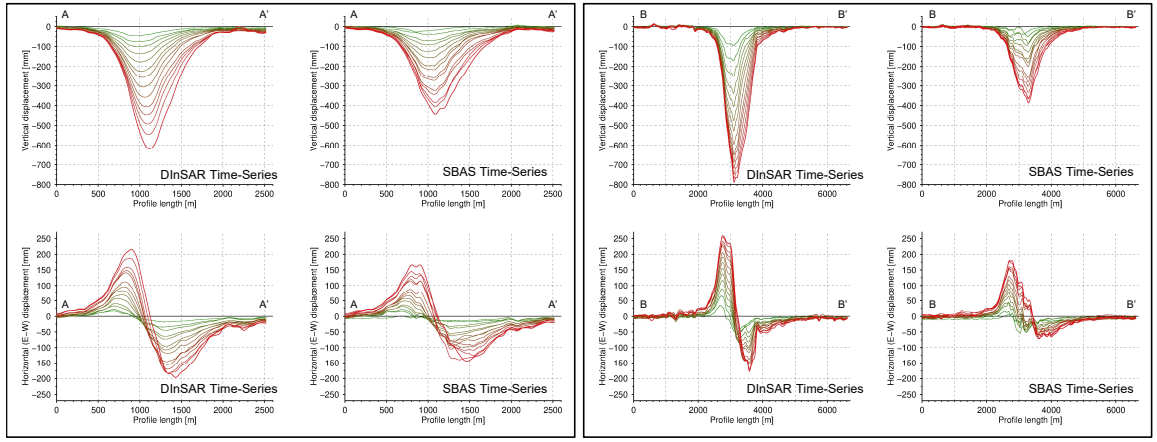

Fig. 3.: Time series profiles of selected subsidence troughs located over the study area. Upper part: vertical displacements compared for results of DInSAR and SBAS time-series. Bottom part: E-W horizontal displacements compared for two selected methods.