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

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Human activity, in particular mining operations are the cause of terrain changes, manifesting on the terrain surface in form of subsidence troughs. Presence of subsidence troughs in inhabited areas may be the cause of significant damage to the structure of buildings, roads and other man-made objects. Both vertical and horizontal terrain displacements occuring inside the trough could be the reason for deterioration of mentioned objects. Hence the need to measure the impact of mining activity on the terrain surface. Current measurement techniques used to determine terrain displacements include GNSS, leveling and SAR interferometry. One of the limitations of interferometric measurements is that displacement values are in the satellites Line-of-Sight (LOS). The fact that the values are only quasi-vertical causes an ambiguity when it comes to determining whether the dominating component of displacement is vertical or horizontal. Projecting the one-dimentional LOS motion to the vertical direction using only the incidence angle can cause significant errors if the magnitude of horizontal motion is considerable. However, the specific 3-dimentional diplacement components can be derived using different acquisition geometries. In order to determine all 3 components (horizontal North-South, East-West and vertical Up-Down), 3 different viewing geometries have to be used so that the equation can be solved. However, the North-South component can be neglected due to low sensitivity of Sentinel-1 SAR instrument to displacement in that direction. Following that, 2 different viewing geometries can be sufficient to derive the East-West and vertical components.

The aim of the study is to determine how mining activity affects the surface in terms of both horizontal and vertical displacements. Radar pairs from Sentinel-1 ascending and descending orbit were used to create interferograms, based on which LOS displacement fields were calculated. The North-South and East-West components of displacement were solved through the inversion of the linear equation system based on incidence angles, headings and LOS displacements of ascending and descending radar pairs.

The horizontal and vertical components were determined for differential interferograms obtained with the DInSAR method using Sentinel-1 imagery, as well as for time series displacement fields derived from the Small Baseline Subset (SBAS) approach over selected mining areas in Poland. The results have shown that data from ascending and descending orbits can be successfully merged in order to obtain both the horizontal (East-West) and vertical components of displacement over

mining areas. Obtained values of displacements from both DInSAR and SBAS have confirmed that areas affected by mining activity are under the influence of changes in height, as well as shifts in horizontal direction. Thus it is important to take into consideration multiple acquisition geometries when it comes to studying deformations over mining areas.