MONITORING OF FAST MINE SUBSIDENCE IN NORTHERN MORAVIA (CZ) USING SAR INTERFEROMETRY

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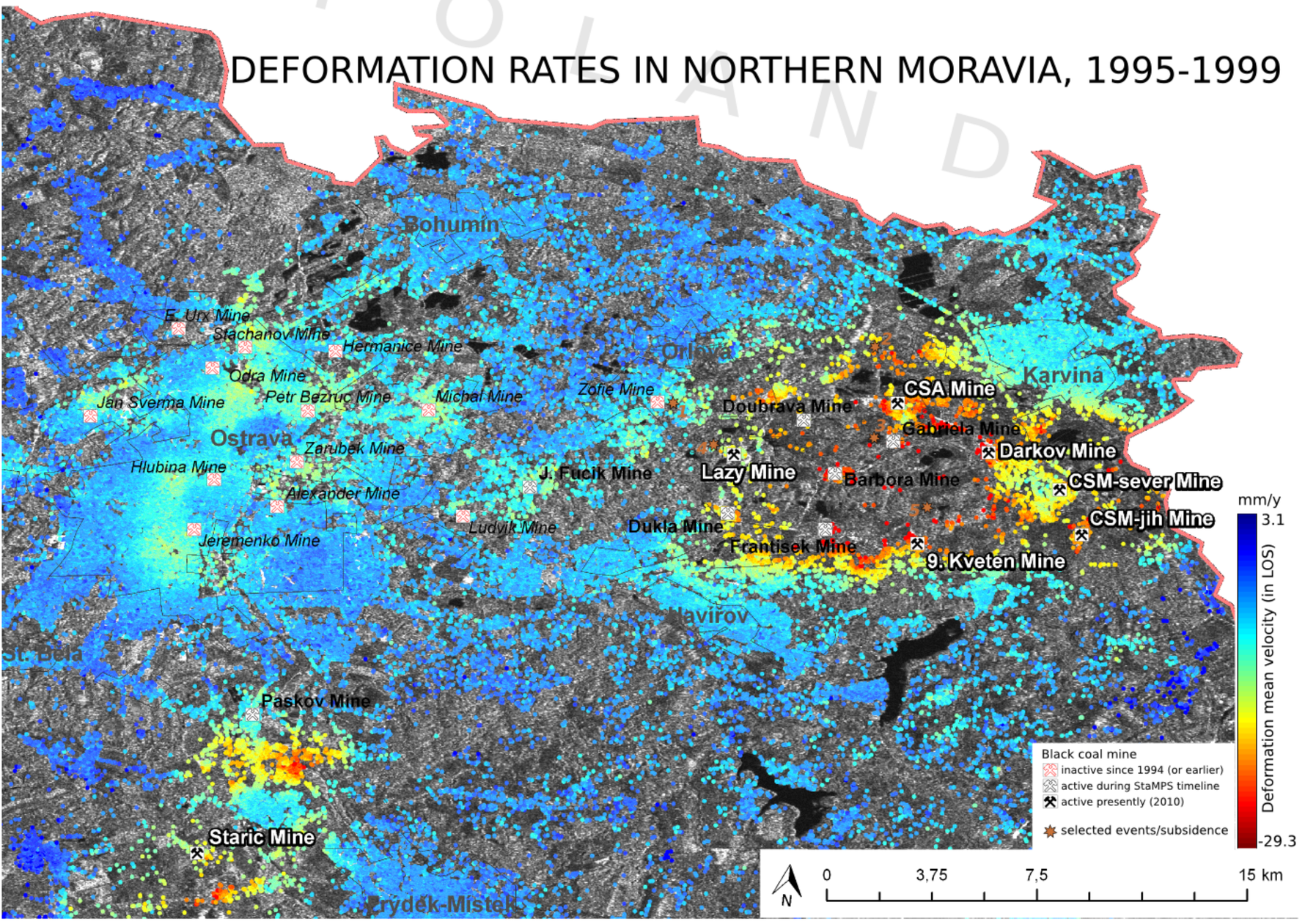
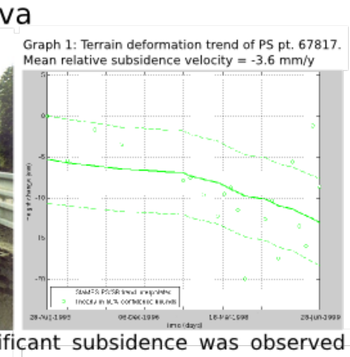
DEFORMATION RATES IN NORTHERN MORAVIA, 1995-1999



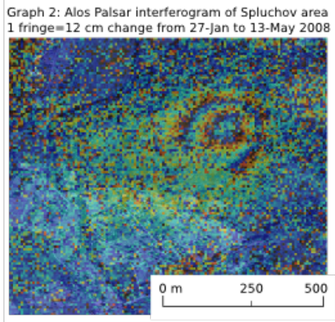
This map figures mean velocities of terrain deformation in Northern Moravia, Czech republic, as computed by StaMPS 3.2 Multitemporal SAR Interferometry processor, from 21 ERS-2 SAR images dating 28-08-1995 - 02-08-1999. The velocity values are related to a stable reference point (not included in the map) at VSB-TU Ostrava.

Tesinska road II/4728, Orlova



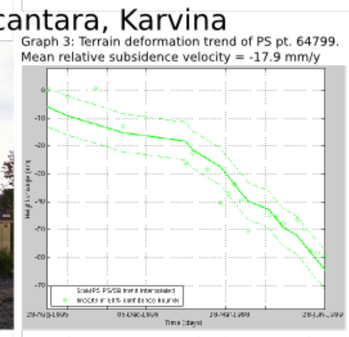
During the years 1997-1999 a significant subsidence was observed nearby already inactive Zofie Mine. During this period, the road has descended for 180cm in maximum. One PS point on the road in a distance of 60m from the disaster was detected (see Graph 1). A fast subsidence is causing visible phase unwrapping errors since 1998.

Doubrava - Spluchov



Spluchov was a densely populated area in Doubrava city. Since 2005, due to new CSA Mine activities it subsides in a rate about 70cm/year.

Church of Saint Peter of Alcantara, Karvina



The church has subsided for 35m since 19th century. It is famous for its inclination of 7° to the south (comparable to Pisa Tower, Italy). The figured PS point is in a distance of 287m from the church.

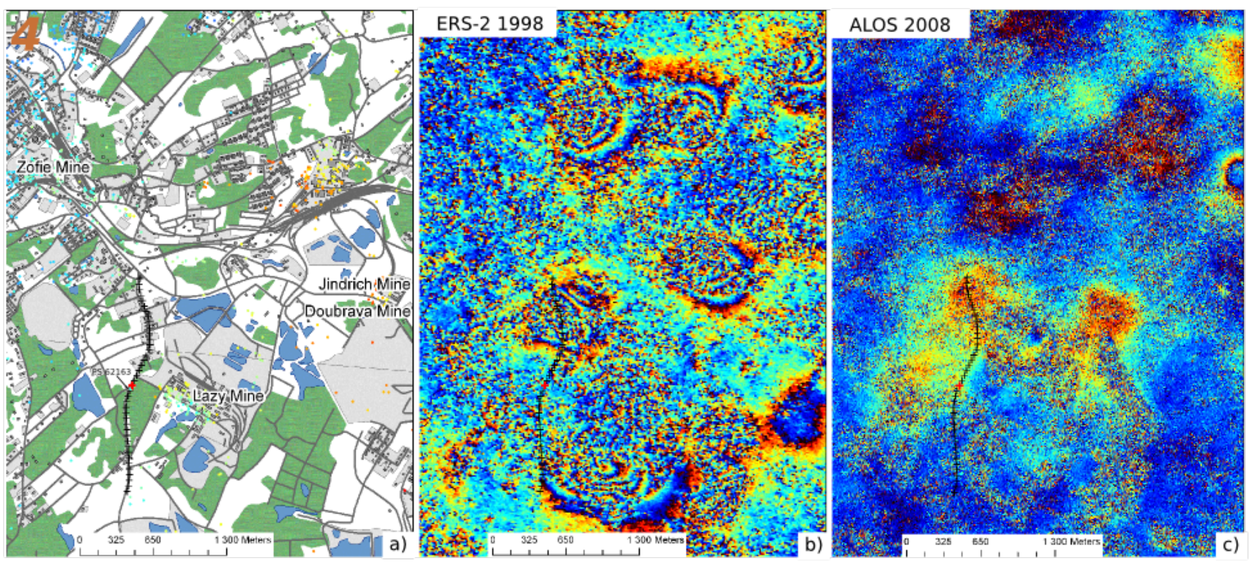
INTRODUCTION

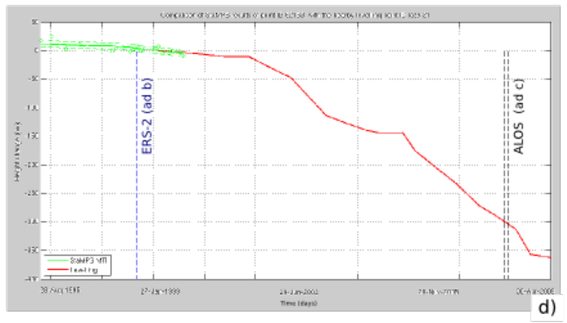
The Northern Moravia region's 1500 km^2 large black coal deposit has been extracted since 18th century. Accordingly to the mining approach, even that mines were not situated directly in populated areas, the region copes with a plenty of civil structures damages.

The real terrain deformation is monitored on places known to subside geodetically - mostly using levelling (mm precision). Testing of C-band satellite synthetic aperture radar interferometry (InSAR) techniques has proven its usability for regional subsidence monitoring. The main difficulties are – a fast subsidence (even more than 2 m/year) often unmeasurable in current InSAR resolution limits and strong regional sources of decorrelation (a dense vegetation cover, high moisture changes in annual periods).

This poster contains a comparison set of different InSAR techniques (differential InSAR, multitemporal InSAR-MTI) using C-band (ERS-2 SAR, Envisat ASAR - wavelength 5.6 cm) or L-band (ALOS PALSAR - wavelength 23.6 cm) radar images and results of levelling in several selected places known to subside in the Northern Moravia region. For the InSAR processing, the Doris 4.2 software, GAMMA (for ALOS PALSAR processing) and StaMPS 3.2 (MTI) has been used. To remove the topography contribution, SRTM3 DEM (year 2000, 3 arcsec. resolution) was used for interferograms < 2002. For later interferograms, Aster GDEM (2000-2009, 1 arcsec. res.) was used. ASTER GDEM is a product of METI and NASA.

MONITORING OF LAZECKA ROAD, ORLOVA





a) Situation map of Lazecka Road area. StaMPS MTI points included
+ levelling campaign points + levelling point chosen for plot in d)

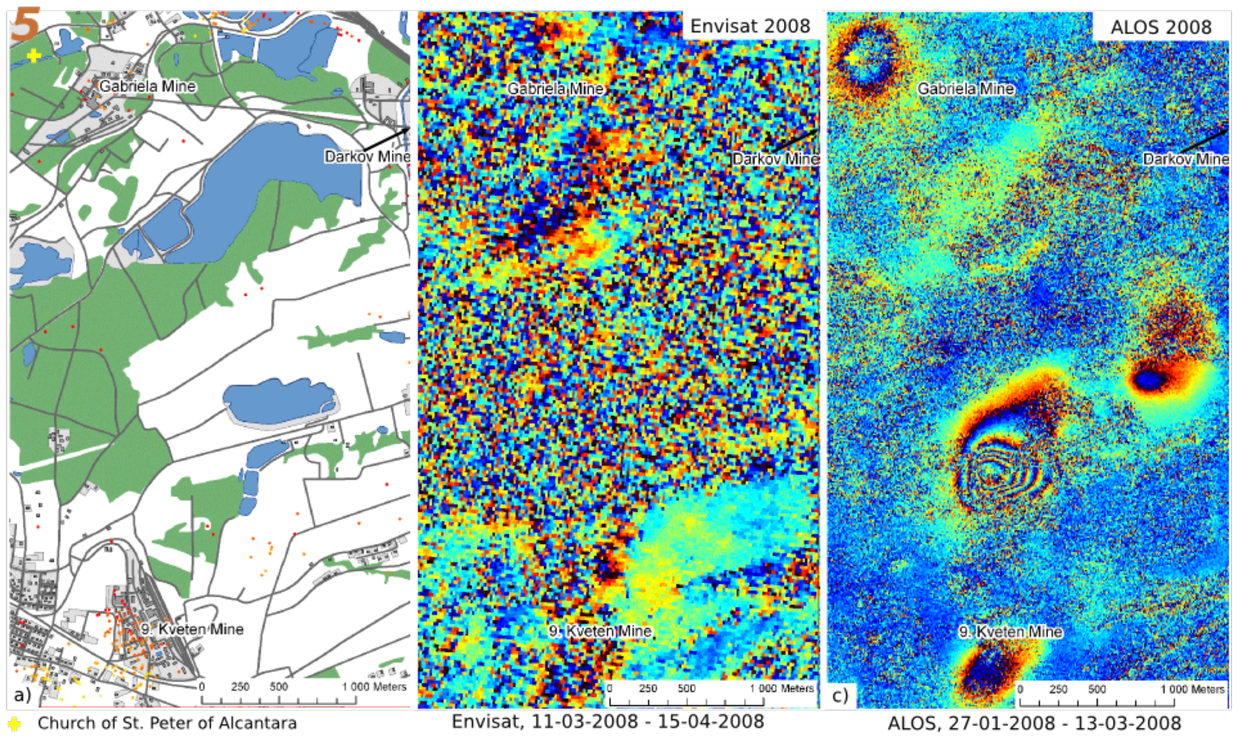
b) Differential interferogram 1998: ERS-2, 23-02-1998 - 30-03-1998
temporal baseline: 35 days perpendicular baseline: 269.6 m
maximal LOS deformation: around 25 cm

c) Differential interferogram 2008: ALOS, 27-01-2008 - 13-03-2008
temporal baseline: 46 days perpendicular baseline: 493.1 m
maximal LOS deformation: around 10 cm

d) Profile plot of levelling point ID 21, with adjacent PS trend plot

Since 1998, a two measurements per year levelling campaign is showing the total subsidence of max. 7m until 2009 in the Lazecka road nearby Lazy Mine, Orlova. The attempts for using C-band data to detect the subsidence mostly failed due to strong decorrelation. The multitemporal analysis has found two PS pixels on the road, apart from the main subsidence basin. In the interferograms the influence of mine activities is readable - since 2007 the Doubrava Mine is inactive; Zofie Mine ended in 1994, Jindrich Mine in 1998, while Lazy Mine is limiting its activity since 1999.

KARVINA MINES MONITORING



Church of St. Peter of Alcantara — Envisat, 11-03-2008 - 15-04-2008 — ALOS, 27-01-2008 - 13-03-2008

The area around Karvina mines (9 kveten, Darkov,...) surroundings is covered mostly by forests and agricultural fields. Mostly this is why C-band interferograms decorrelate. L-band waves penetrate through vegetation cover much better. The ALOS interferogram can distinguish a high rate of subsidence in a higher pixel resolution. The center artefact in the image subsides in a LOS deformation rate of around 66 cm per 46 days. On the ALOS interferogram, the subsiding area around the church of St. Peter of Alcantara is captured. Note that the nearby Gabriela Mine ended its activities in 2004. An undermined area can impact the surface during a wide time scale.

CONCLUSIONS

The fast subsidence present in the Northern Moravia aggravates its monitoring using InSAR. As one of the solution, L-band SAR data were used. The ALOS PALSAR has a longer acquisition period (46 days) than ERS/Envisat (35 days), but its range resolution is much higher (PALSAR Fine Mode: 7 m, ASAR Image Mode: 30 m). Its longer wavelength allows to measure larger deformations per pixel (PALSAR: 11.8 cm, ASAR: 2.8 cm) and to avoid decorrelation by vegetation/other small scatterers.

The StaMPS MTI processing has succeeded in detection of longtime subsiding places. Because of a fast subsidence that easily exceeds mentioned pixel resolution, the MTI results are mostly underestimated.

Several disasterous events were searched interferometrically, such as an abrupt descend of Doubrava Mine tower on 28th July 1998. Unfortunately, without any interpretable signs.

ACKNOWLEDGMENTS

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