LONGTIME MONITORING OF MINE SUBSIDENCE IN NORTHERN MORAVIA, CZECH REPUBLIC USING DIFFERENT INSAR TECHNIQUES

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1. INTRODUCTION

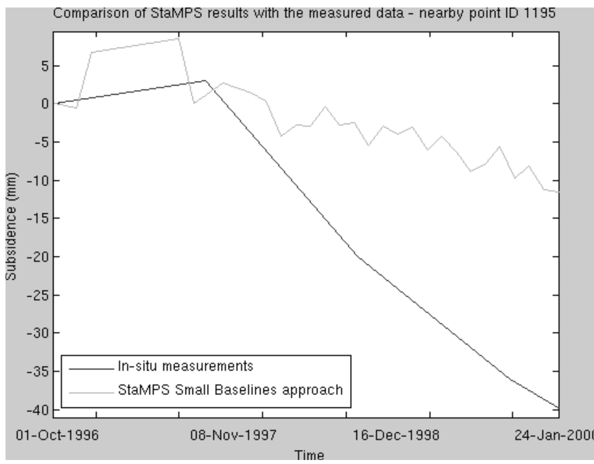
Northern Moravia region is famous for its huge black coal deposit in an area of about 1500 km^2, with heights of even tens of meters. Extensive mining activities since 18th century cause fast subsidence in the cities of Karviná, Orlová, Havířov, its surroundings and surroundings of Ostrava city (OKR area). In the most critical areas the rate of subsidence exceeds 1 meter per year, even in populated places. During last decades, the land deformations are measured using technical levelling techniques to create maps of subsidence. Since 2008, an ESA CAT-1 project is operating with a view to prove a usability of radar interferometry (InSAR) techniques to monitor the subsidence in higher effectivity.

2. DIFFERENTIAL INSAR PROCESSING

First, the differential InSAR (DInSAR) attempt has been applied at all available data, in all possible combinations (with regard on source sensor) - 12 ERS-1, 106 ERS-2 and 10 Envisat ASAR images covering the period of time 1996-2009. An SRTM3 DEM was applied to remove topological phase patterns and several enhancing filters implemented in the DORIS software. In the end, only about 14 interferograms represent visually interpretable subsidence detection. The rest of interferograms are strongly decorrelated – amongst other reasons, mostly due to a dense vegetation cover and a strong atmospheric pollution in this industrial area. As a result, only subsidence evolution during 1996-2001 could have been mapped using this methodology. Only one pair of Envisat data from 2008 has been processed properly.

3. MULTITEMPORAL INSAR PROCESSING

Using StaMPS software and Delft PS Toolbox software, a Persistent Scatterers (PS) technique was applied to a set of 21 ERS-2 images from 1999-2000. Also, a Small Baselines approach (SB) has found more stable pixels in the same dataset (in this densely vegetated area, there is a relatively low amount of dominant scatterers) – this approach was also successful in larger set of images from 1996-2000. Newer ERS-2 acquisitions were not used because of too high Doppler centroid frequency differences due to a gyroscopes failure of ERS-2 on January 2001. As a result, the PS+SB points localized correctly the subsidence in the area, but the velocity of subsidence has been strongly underestimated because of several reasons such as a high subsidence rate in the area exceeding the detectable phase value of a pixel, possibly unstable reference point used for the techniques, decorrelation effects, StaMPS algorithms for phase unwrapping that don't take a temporal deformation trend into account etc.



Graph 1 - Comparison of StaMPS SB pixel with levelling measurements of a nearby located point

4. COMPARISON WITH LEVELLING

In the area, about 400 levelling points are being measured. Several levelling points that were situated nearby detected PS/SB points (less than 50 m distance), were selected for a comparison with the StaMPS estimation of subsidence. In places with a fast (decimetres) subsidence, the estimation is strongly underestimated (max. estimated value was -4.2 cm relatively to the reference point). One of these comparisons is figured in the Graph 1 showing the wrongly unwrapped phase values of an SB point (lighter colour) situated nearby a levelling point (dark line).

4. MONITORING IMPROVEMENTS

During the year 2010, a project for improving monitoring results is to be applied. It consists in installation of several corner reflectors, designed and placed optimally for Envisat scanning, on critical places, where the received signal in most of radar acquisitions is not intensive enough. At these corner reflectors, a GPS receiver is to be installed to get the precise positions of the reflectors and to measure the atmospheric influence on phase variation using a GPS meteorology technique, to filter this atmospherical contribution regarded as a noise to deformation signal. Also, Alos PALSAR images are to be used in DINSAR application to enhance the results – it is an instrument scanning in L-band wavelengths that penetrate through vegetation much better than C-band instruments (Envisat ASAR,...) and is better suited to detect large subsidence in small area, as it is in this particular case. Also, a modified algorithm for phase unwrapping will be used in StaMPS in the future work for better subsidence velocity estimations.

5. CONCLUSIONS

The InSAR processing of the mining area proves that it is possible to detect the land deformation from the satellite radar acquisitions. The multitemporal InSAR techniques are useful at least for coarse estimation of the subsidence progression, but the very fast subsidence is not detectable in sensitive methods of PS or SB. Because of depicted (and other) problems computing the interferograms in this particular application, it seems that it cannot fully replace the terrain measurements in the area. The dataset of ERS satellites until 2001 is applicable in InSAR to get an overview of land deformations progression, this wasn't achieved with newer Envisat data, though (the reasons are still being investigated). After newer images will be processed correctly, it would be possible to conclude on the subsidence evolution in the full time scale. Since 2007, most of mines has ended their activity – it would be interesting to observe a delay of the impact of their closure on the surface deformations. A future plan is depicted in part 4 - the depicted monitoring improvements are to be held during year 2010 or later on.

11. REFERENCES

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