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Satellite synthetic aperture radar for monitoring of surface deformation in shallow underground mining environments

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Surface deformations associated with shallow underground mining activities have significant implications for both the natural- and built environment. Environmental problems include the exacerbation of acid mine drainage and the alteration of hydrological pathways. Ponding water also sterilises the area of agricultural production. In the built environment, subsidence basins can cause damage to high value infrastructure networks such as roads, pipelines and electrical distribution networks. There are also human health-and-safety concerns in potentially unstable areas. To monitor the extent of deforming areas over time, ground-based surveys, including GPS and spirit-levelling techniques, are frequently employed. However, the process is time-consuming and labour intensive and virtually impossible to implement over large areas. It is also dangerous to send survey personnel into potentially unstable regions. High resolution airborne surveys are also frequently commissioned. However, these surveys are prohibitively expensive and are therefore used infrequently.

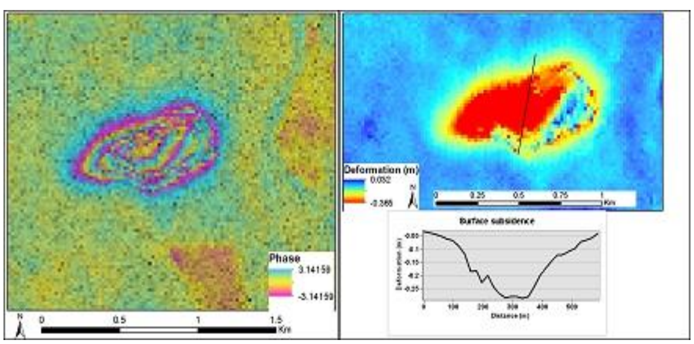

Figure 1: Differential interferogram and associated deformation map over an area undergoing mining-induced subsidence

Synthetic aperture radar (SAR) data is known to provide cm to mm scale deformation measurements through a technique known as differential interferometric synthetic aperture radar (dInSAR) [4]. To test the ability of dInSAR data to operationally measure mining induced surface deformation, data was collected over an operational coal mine in the Witbank Coalfields, South Africa [1]–[3]. Data analysis focussed on C-band and L-band data captured at various polarisations to test the operational limitations of using dInSAR techniques using real-world deformation phenomena as test case [2]. The results of the analysis revealed that both C- and L-band data could be used for the ongoing measurement and monitoring of mining-induced deformation. C-band data were more likely to be affected by vegetation noise, particularly during the peak of the growing season [1]. On the other hand, the longer wavelength L-band data were more likely to penetrate through vegetation, thereby minimising the interaction with vegetation, and decreasing the signal noise [3]. Therefore, L-band data were considered to be optimal for monitoring surface deformation in the region of interest.

The advantage of using dInSAR is that large areas can be monitored in a single footprint. Satellites also orbit the meaning that frequent measurements can be made. Since measurements are made remotely, dInSAR effectively overcomes the limitations imposed by field-surveying techniques. Although L-band data is considered to be more robust due to the decrease in signal interference by vegetation, both C- and L-band data could be used for long-term operational monitoring.

References:

[1] Engelbrecht J, Musekiwa C, Kemp J and Inggs MR (2014) Trans. Geosci. Remote Sens., 52(3): 1572–1582| [2] Engelbrecht J (2013) Parameters affecting interferometric coherence and implications for long-term operational monitoring of mining-induced deformation," University of Cape Town.
[3] Engelbrecht J and Inggs MR (2013). South African J. Geomatics, 2(2): 82–93, 2013.
[4] Massonnet D and Feigl KL (1998). Rev. Geophys 36(4): 441- 500