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Capturing pre-failure signs of slope instability using multi-temporal interferometry and Sentinel-1 data

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The shorter repeat cycle (6 days since October 2016) and regularity of acquisitions of Sentinel-1A/B with respect to earlier European Space Agency (ESA) satellites with C-band sensors (ERS1/2, ENVISAT) represent the key advantages for the research-oriented and practical applications of multi-temporal interferometry (MTI). The applicability of the Interferometric Wide Swath acquisition mode of Sentinel-1 (images covering a 250 km swath on the ground) to regional scale slope instability detection through MTI has already been demonstrated, e.g., via studies of landslide-prone areas in Italy. Here we focus on the potential of Sentinel-1 data for local (site-specific), MTI-based monitoring and capturing pre-failure signs of slope instability, by exploiting the Persistent and Distributed Scatterers processing capability of the SPINUA algorithm. In particular, we present an example of a retrospective study of a large (over 2 km long) landslide, which took place in 2016 in an active open-cast coal mine in central Europe. This seemingly sudden failure caused destruction of the mining equipment, blocked the mining operations thereby resulting in significant economic losses. For the study, we exploited over 60 Sentinel-1A/B images acquired since November 2014. The MTI results furnished a valuable overview of the ground instability/stability conditions within and around the active mine, even though considerable spatial gaps in information were encountered due to surface disturbance by mining operations. Significantly, the ground surface displacement time series revealed that the 2016 slope failure was preceded by very slow (generally 1-3 cm/yr) creep-like deformations, already present in 2014. The MTI results also indicated that the slope experienced a phase of accelerated movement several weeks prior to the landslide event. Furthermore, the spatio-temporal analysis of interferometric coherence changes in the unstable area (mapped on Sentinel-2 Bottom Of Atmosphere reflectance images processed by using the ESA Sen2Cor processor), indicated a sharp coherence loss in the last few weeks before the slope collapse. The availability of more frequent measurements represents a key improvement for MTI-based ground surface displacement monitoring and this will better support research on slope destabilization processes over time and, ultimately, on slope failure forecasting.

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