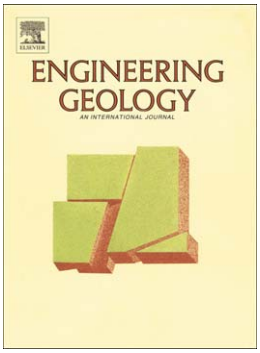

Using advanced InSAR techniques to monitor landslide deformations induced by tunneling in the Northern Apennines, Italy

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Using advanced InSAR techniques to monitor landslide deformations induced by tunneling in the Northern Apennines, Italy

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Abstract

Synthetic Aperture Radar (SAR) interferometry (InSAR) is used to make measurements of small surface displacements in different situations including ground-settlement, landslides and excavations. We document the deformation history of four dormant deep-seated landslides in the Northern Apennines of Italy that were reactivated by the excavation of a double road tunnel. The tunnel is part of a larger infrastructure project that involves the improvement of the A1 highway which connects Bologna and Florence. The excavation of the tunnel under the landslides' basal shear surfaces started in 2011, and with the advance of the tunnel front, deformation began to occur, causing damages to homes and infrastructures. The tunnel passes under the small villages of Ripoli and Santa Maria Maddalena. The deformation slowed down after the tunnel was completed in November 2014, and low surface displacement rates were registered for the period between October 2014 and June 2016. We show the results of an InSAR analysis designed to measure surface movements between 2003 and 2016. The InSAR displacements are derived from the Envisat, COSMO SkyMed, and Sentinel 1 datasets and cover the main construction phase of the tunnel (2011-2015). A detailed geological and geomorphological mapping of the slope is developed based on the field evidence and on the spatial pattern of surface deformation provided by our InSAR analysis. Together with the map, a new conceptual geological model of the slope in tectonically sheared and weathered flysch is presented. The satellite InSAR data show good agreement with available ground based monitoring data that include inclinometer and GPS-measurements, while small differences occur with respect to deformation time series obtained from a ground-based InSAR instrument. In particular, the InSAR results for the X-Band data of COSMO SkyMed demonstrate the close relationship between the position of the excavation front and the displacement rates of previously dormant landslide de-