



Small-scale ground settlements induced by tunnelling detected by Sentinel-1 SAR interferometry

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Excavation of tunnels can modify the hydrological regime around an excavated area and might induce generalized surface subsidence due to pore pressure variations. This induced subsidence ratio can cause severe damages to the man-made structures located in proximity of the tunnel and, for this reasons, an accurate survey of surface deformation before, during and after construction is of high importance. Synthetic Aperture Radar (SAR) interferometry is a powerful monitoring technique to obtain with millimeter accuracy measurements of surface displacements. In particular, the Sentinel-1 satellite mission nowadays provides extensive spatial coverage, regular acquisitions and open availability. This work documents a Synthetic Aperture Radar Multi Temporal Interferometry (MT-InSAR) analysis showing the spatio-temporal evolution of ground displacements arising from the construction of a 3.71 km overflow tunnel in Genoa city (Italy). The tunnel was excavated beneath a densely urbanized area lying on marly limestones and clays. Significant cumulative displacements up to 30 mm in the Line of Sight (LOS) direction were detected during the tunnel excavation. The high density of detected targets permitted to enhance our understanding of the ground-settlements patterns in space and their spatio-temporal progression. Transverse subsidence profiles were made perpendicularly over the tunnel trajectory, showing a clear correlation with the excavation works in a buffer zone of max 500 m circa for each side. The time-series highlight a good correlation with the tunnel face advancement, which triggered the subsidence phenomena proceeding northward from middle 2016 to the end of 2017. The re-stabilization of the subsident area occurred in about five-six months from the beginning of each displacement phase. Due to the low subsidence ratio the ground settlements did not cause severe damages to the buildings. This study demonstrates the usefulness and the great importance of Sentinel missions which supply worldwide covering free and open-access data. Achieving the same spatio-temporal resolution and accuracy with conventional surveying methods can involve much higher costs, especially in areas that need extended coverage. The obtained results could also be significant for the development and calibration of numerical models to be employed to simulate the expected ground settlements in urban environments during each phase of the tunnelling works, from the design to the monitoring after the construction. Outcomes of this analysis might be useful especially in this area, which shortly will be crossed by a new railway subway infrastructure and the Bisagno river overflow tunnel.