Monitoring land subsidence and element at risk in the Po Delta area (Northern Italy) through MT-InSAR and GNSS surveys

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Delta areas are more likely to suffer from land subsidence due to tectonic and geological processes. Po Delta evolution shows a succession and superposition of complex processes caused by both natural and anthropogenic factors. The factors include sediment loading and compaction, post-glacial rebound, coastal flooding and erosion, sea level rise, land use changes, underground resources exploitation, population growth and urbanization. The natural subsidence has been estimated in the order of millimeters per year and the anthropogenic subsidence is greater than 10 mm/year. Several areas are located under the mean sea level and are exposed to flooding. These areas have been protected by embankments which represent a crucial element for flood risk mitigation. Multi-temporal interferometric synthetic aperture radar (MT-InSAR) and global navigation satellite system (GNSS) allow the continuous monitoring of land subsidence and structures and infrastructures deformations. The Po Delta landscape is characterized by large mudflats, farmland, and wetlands, and a low level of urbanization. Interferometry survey is difficult in this area, due to the temporal decorrelation caused by variations of the scattering properties associated with soil moisture and volume scattering, especially in the case of summer acquisitions. Then, MT-InSAR has to be integrated with ground-based measurements techniques which are costly and time consuming. In this study, MT-InSAR and GNSS techniques are combined to monitor the land subsidence and the deformations of the elements at risk, in particular the flood protection infrastructures. C-band Sentinel-1 and X-band COSMO-SkyMed SAR data acquired in 2014-2020 and 2012-2020, respectively, are considered. An MT-InSAR technique is exploited using the interferometric point target analysis (IPTA) method, making a network of targets including both distributed scatterers (DS) and persistent scatterers (PS). GNSS data have been collected by 3 permanent stations and 46 non-permanent stations (NPS) distributed in the Po Delta. The NPS were measured during three survey campaigns in 2016, 2018, and 2020. Results from MT-InSAR applied to Sentinel-1 data and GNSS techniques are compared and integrated to estimate the subsidence rates for most of the area. The monitoring of the embankments is possible using COSMO-SkyMed data due to their high resolution and high backscatter on structures and infrastructures. For future studies, the regression analysis between the natural/anthropogenic processing and the land subsidence of the Po Delta area can be performed to identify the major driving factors of the deformations in the different periods, which can improve the risk mitigation.
strategies.