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Characterization of the multi-component driving land subsidence using Persistent Scatterer Interferometry technique: the Ravenna case of study (Italy)

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Land subsidence represents a kind of hazard, which affects an increasing number of worldwide regions, densely populated, causing damage to the environment and infrastructures. Settlements can be related to multiple processes both natural and anthropic (i.e. vadose zone processes, soil consolidation, aquifer compaction, solid and fluid extraction and load-induced compaction) which take place at different spatio-temporal scale. Over the last decades, advanced subsidence studies exploited Synthetic-Aperture Radar (SAR) data, a recent remote sensing tool, to investigate land subsidence phenomena around the world. In particular, Persistent Scatterer Interferometry (PSI) technique, allowing a quantitative estimation at high resolution of the surface deformations, has already been successfully applied to monitor the phenomenon evolution; PSI measurements represent the cumulative displacement, deriving from the contribution of natural and anthropic components, both superficial and deep. The overlapping of several causative factors makes more difficult to accurately interpret the resulting deformations; therefore, it is essential to implement a suitable methodology to distinguish the shallow and deep components of motion.
The aim of our research is to introduce a PSI-based approach not only to monitoring but also to understand the land subsidence mechanism, in order to disentangle the natural and anthropic components of motion. The methodology consists of three main phases: 1) Post-processing elaborations (i.e. interpolation of the cumulated displacements and isokinetics map implementation); 2) Characterization of the subsidence areas (i.e. subsidence pattern recognition by means of automatic time series classification); 3) Mechanisms recognition (i.e. identification of the predisposing and triggering factors and comparison with lito-technical model of subsoil, and with earth measurements).
In this work, the methodology has been applied to the Ravenna area, Italy, using images acquired by ERS-1/2 (1992-2000), ENVISAT (2003-2010) and TERRASAR-X (2012-2014) sensors. The test site is located in the south-eastern sector of the Po River plain, along the Adriatic Sea, where there are present around 1500-3000 m of Quaternary deposits, mainly constituted by sandy and silty-clay layers of alluvial and marine origin. These sediments lay on a pre-Quaternary substratum characterized by buried active thrusts, which are parallel to the Apennine alignment. The particular geological context deserves special attention, because it hosts several municipalities and relevant infrastructures, where a long-trend of subsidence rate has been recorded over the last decades, representing the result of superimposed phenomena: tectonic, depositional, climatic and man-induced processes.
The definition of the multi-component contribution is intended as a crucial step towards a more reliable subsidence prediction model, which, in turn, will help to better calibrate the suitable remedial measures as to prevent further ground deformations of this important coastal lowland.