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National scale full-resolution P-SBAS processing for the investigation of critical infrastructure deformations related to the built-up environment

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Differential Interferometric Synthetic Aperture Radar (DInSAR) techniques have emerged as powerful tools for monitoring and surveillance at both single-building and territorial levels, offering sub-centimetric accuracy with manageable costs. Among these techniques, the DInSAR method known as Small BAseline Subset (SBAS) and its parallel algorithmic implementation, referred to as the Parallel SBAS (P-SBAS) approach, stand out for their ability to provide systematic displacement measurements at both regional, national and continental scales through the generation of spatially and temporally dense deformation time series, contributing to investigate various hazard scenarios related to the natural and the built-up environments. Moreover, by exploiting the full-resolution extension of the P-SBAS approach, it is also possible to generate long-term deformation time series at different spatial resolution scales for regional and local displacement investigations.

This work focuses on the extensive use of the full-resolution P-SBAS approach for local-scale DInSAR analyses aimed at detecting localized deformation phenomena in wide urban areas, with a particular interest in infrastructure and individual building displacements. To this aim, we can profitably capitalize on the highest spatial resolution of the SAR images collected by the currently available and future advanced satellite SAR systems characterized by different operational modes (Stripmap, TOPSAR, ScanSAR) and frequency bandwidths (L-, C-, and X-band).

Among these, we leverage the extensive archives of X-band (about 3 cm wavelength) SAR data acquired since 2009 along the overall Italian territory by the sensors of the Italian COSMO-SkyMed constellation of the first (CSK) and second (CSG) generation, operated through the Stripmap mode (about 3 m x 3 m spatial resolution) within the so-called Map Italy program. This huge SAR dataset makes it possible to monitor the surface deformations affecting the built-up environment with a very high spatial and temporal measurement density. In this work, we perform a full-resolution P-SBAS analysis over some Italian cities (e.g., Roma, Napoli, Bologna, Catania), where large

sequences of ascending and descending CSK/CSG SAR data are available, in order to assess the health conditions of critical infrastructures and buildings related to extended built-up environments. Moreover, we also present the preliminary full-resolution P-SBAS results achieved by processing the available L-band SAR data acquired by the new twin sensors of the Argentinian SAOCOM-1 constellation of CONAE (spatial resolution about 5x5 m). Thanks to the longer wavelength characterizing the L-Band data, we can investigate the possibilities of overcoming some of the typical limitations of X-band SAR systems (e.g., the occurrence of phase unwrapping problems). Our approach involves the use of parallel hardware and software solutions, including GPU parallel programming techniques, which prove to be highly effective in rapidly generating full-resolution P-SBAS deformation time series over large urbanized areas. These measurements can help to define a roadmap for identifying and preventing critical conditions in buildings and infrastructures.