The parallel implementation of the full resolution SBAS-DInSAR processing chain for surface deformation analyses in extended urban areas

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The large availability of Synthetic Aperture Radar (SAR) data collected over the last decade by several satellite missions, such as COSMO-SkyMed, TerraSAR-X and Sentinel-1 constellations, has been pushing toward the present Earth Observation (EO) scenario into a “golden age”, which is rapidly moving towards a real Big Data scenario. The widespread use of satellite SAR data have fostered the development of several SAR applications, one of those referred to as Differential SAR Interferometry (DInSAR) technology, which has deeply demonstrated to profitably detect the surface deformations over a wide spatial extent in both natural and anthropic hazard scenarios, through the generation of spatially dense deformation maps with millimetric accuracies. In particular, the advanced DInSAR algorithm referred to as Parallel Small BAseline Subset (P-SBAS) approach allows retrieving the temporal and spatial characteristics of the detected displacements at two spatial resolution scales, referred to as regional (spatial resolution in the 30-90 m range) and local (spatial resolution in the 3-10 m range) scales, suitable for a large variety of application fields, from natural hazards (volcano eruptions, seismic events, landslides) to anthropic contexts (urban areas, archaeological sites, oil-gas extraction, structures and transport infrastructures).

However, the interferometric processing performed at local scale needs to deal with hundreds of SAR acquisitions at full spatial resolution, i.e. to manage several hundreds of million points; consequently, the processing of such a data amount is particularly heavy from a computational point of view and can not be carried out in reasonable time frames through the traditional (sequential) implementation of the full resolution DInSAR processing chains.

Accordingly, to profitably benefit from the current SAR scenario, it is crucial to develop innovative solutions to automatically and efficiently handle large DInSAR data stacks. These solutions are principally based on the exploitation of advanced distributed computing environments, to achieve high efficiency in terms of scalability performances, as well as on the development of much more advanced DInSAR methodologies (and codes) able to effectively maximize the information related to these huge amount of DInSAR data.
This work is aimed at describing an innovative DInSAR solution, based on the exploitation of distributed HPC and Cloud Computing environments, which benefits from parallel programming techniques (multi-node, multi-threads, GPUs) implemented within an automatic full resolution P-SBAS processing pipeline. Starting from large SAR datasets acquired by the COSMO-SkyMed constellation, the developed parallel full resolution P-SBAS processing chain allows retrieving in short time frame (less than 24 hours) displacement time series and deformation maps, at the single buildings/infrastructure level, relevant to extended urban areas. The presented experimental results and the related performance analyses are achieved by applying the developed parallel P-SBAS pipeline to a number of large full resolution COSMO-SkyMed datasets acquired over some important Italian cities (e.g. Rome and Naples urban areas).