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Deformation time series via space-borne radar interferometry: a second generation tool for Earth's surface displacement analysis

Eugenio Sansosti
IREA, National Research Council (CNR), Napoli, Italy (sansosti.e@irea.cnr.it, +390815705734)

Differential SAR Interferometry (DInSAR) is a well known microwave remote sensing technique that enables the measurement of surface deformation with a large spatial coverage capability. "First generation" (or "classical") DInSAR methods exploit the phase difference (interferogram) between couples of SAR images of an investigated area from temporally separated observations and provide a measurement of the ground deformation, projected along the radar line of sight (LOS), occurred within the considered time interval. This approach has been applied to study a large variety of natural and anthropogenic phenomena and represents nowadays a widely used tool for detection and mapping of surface displacements over large spatial scales.

Over time, the interest of the scientific community has progressively moved from the investigation of single deformation episodes (earthquakes, volcano eruptions, etc.) toward the study of the temporal evolution of the detected displacements through the development of "second generation" (or "advanced") DInSAR techniques. In this case, the information available from a sequence of DInSAR interferograms is simultaneously used to generate a deformation time series for each coherent point (i.e. where the phase information is preserved) included in the studied area.

Regardless of the specific approach or its particular implementation, the advanced algorithms offer many advantages with respect to classical DInSAR. First of all, atmospheric artifacts can be detected and filtered out because of their different space-time behavior with respect to the deformation signal. Second, topography artifacts and phase unwrapping errors can be mitigated by using the space-time data redundancy. Moreover, possible orbital phase errors can be effectively compensated for by using the measurements of a limited number of GPS stations. All these characteristics contribute to improve the measurement final precision up to about 0.5–1 mm/year and 5–10 mm for deformation velocity maps and time series displacements, respectively.

Once advanced DInSAR approaches have been established as new, precise and reliable techniques for measuring ground deformation, one could wonder whether the precision improvement is the only advantage attainable to the expense of an increased data processing complexity. In fact, although this is a noteworthy result, the possibility to generate deformation time series itself represents an inherent added value of second generation DInSAR techniques

The aim of this work is to show how the spatially dense deformation time series can effectively give a deeper insight into the geophysical analysis of natural phenomena that, probably, could not be investigated with the same detail via classical DInSAR techniques. This is done by exploiting some of the available large C-band (5.6 cm wavelength) SAR data archives, collected by the ERS-1, ERS-2 and ENVISAT sensors of the European Space Agency; in this case it is also possible to combine these multi-platform data to carry out very long term DInSAR investigations.

In addition, the advances brought in by the new generation X-band (3.1 cm wavelength) space-borne SAR sensors, characterized by high spatial resolution and short revisit times, are also considered and highlight new investigation possibilities for fast varying deformation phenomena. This is done by exploiting data from the COSMO-SkyMed sensors operated by the Italian Space Agency that are used to show post-seismic deformation occurred in L'Aquila (Italy) following the April 6, 2009 earthquake.