INSAR DATASTACKS FOR VOLCANO MONITORING: POTENTIAL AND DRAWBACKS

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ABSTRACT

During the last decade DInSAR (Differential Synthetic Aperture Radar Interferometry) has been used to study a wide range of surface displacements related to seismic faults, volcanoes, landslides, aquifers, oil fields and glaciers, to name just a few, at a spatial resolution of less than 100 m and cm-level precision.

Differential Interferometry (DInSAR) provides accurate deformation estimates covering large spatial areas and are derived based upon measured differences from a reference DEM of the area. For each pixel, it is possible to compute the expected phase based upon the reference DEM, satellite position and the known viewing geometry of the acquisitions. Any deviation in the phase is attributed to some combination of atmospheric effects, DEM "error", topographic deformation and sensor noise. When the concept is extended to include multiple SAR satellite acquisitions, a deformation time series can be generated and presented visually for further analysis and geophysical modelling.

The Permanent Scatterer method (PSInSAR™), developed by Politecnico di Milano (POLIMI) and further improved by TRE (a POLIMI spin-off) has been introduced in the late nineties as an advanced InSAR technique capable of measuring millimeter scale displacements of individual radar targets on the ground by using large multi-temporal data-sets collected over the area of interest, estimating and removing the atmospheric components affecting the acquisitions. After the pioneering work of POLIMI and TRE, other techniques (CTM, IPTA, SBAS and more) have followed similar strategies and have shown promising results in many different scenarios.

Using the PS technique, it is possible to retrieve the velocity field over large areas (thousands of square kilometres) with an accuracy even better than 1 mm/yr, by identifying a set of coherent targets, such as individual buildings or rock outcrops, not previously exploited in traditional SAR interferometry and then computing their displacement time series and range-change rates.

For the study of volcanic areas, PSInSAR™ provides both a global and a detailed view of the area of interest, allowing the monitoring of surface deformation related to the dynamic of magmatic systems and providing useful data for the modeling of the volcanic system. Indeed, the application of InSAR techniques to poorly monitored areas could be a key tool for assessing volcanic hazards. For example the "natural geodetic network" generated by the PS population identified over the area under study could be used to recognize volcanic precursors that identify re-activation at a mid and long term, possibly integrating EO data with other in situ monitoring systems.

This contribution focuses on the results of the application of the Permanent Scatterers Technique (PSInSAR^{TM}, an advanced InSAR technique capable of measuring millimetre scale displacements of individual radar targets on the ground) as a method for measuring deformation in volcanic area within the Globvolcano project (ESA, Data User Element program).
Three cases of PSInSAR^{TM} application are presented: Piton de la Fournaise (Reunion Island), Stromboli and Volcano (Eolie, Italy). More than 200 ENVISAT ASAR scenes have been processed to estimate the velocity field of the volcanoes surface, as a consequence of the magmatic camera evolution; time series of displacement have been extracted and, whenever possible, ascending and descending geometry dataset have been jointly exploited in order to produce vertical and easting displacement maps.
The test cases presented will give the opportunity to describe the enhancement applied to the PSInSAR^{TM} processing chain, required to make the algorithm capable to cope with the complex volcanic deformation dynamics such asabrupt changes, non-linear motion.