Geophysical Research Abstracts, Vol. 9, 03724, 2007
SRef-ID: 1607-7962/gra/EGU2007-A-03724

The SBAS-DInSAR approach for surface deformation analysis of active volcanic areas

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Abstract

Differential Synthetic Aperture Radar Interferometry (DInSAR) is an active microwave remote sensing technique that allows us to produce spatially dense deformation maps with centimeter to millimeter accuracy. An effective way to detect and follow the temporal evolution of deformation is via the generation of time-series; to do this, the information available from each interferometric SAR data pair must be properly related to those included in the other ones, via the generation of an appropriate sequence of DInSAR interferograms. In this context, several approaches have been already proposed. Among these procedures, we consider the one referred to as Small BAseline Subset (SBAS) approach [1] that implements an appropriate combination of the DInSAR interferograms generated from SAR images pairs characterized by a small spatial and temporal separation (baseline) between the acquisition orbits. We remark that the SBAS algorithm allows us to exploit averaged (multilook) interferograms; this permits to reduce the amount of data to be processed, thus simplifying the analysis of extended areas (typically of about 100X100 km). This possibility allows us to highlight the relationships between local deformation patterns, i.e., displacements due to a volcanic source, and regional patterns associated to a tectonic process.

In this work we present several experiments relevant to different volcanic areas. The presented results are based on the exploitation of ERS and ENVISAT SAR images and

are focused on Long Valley caldera (California), Tenerife Island (Spain) and Campi Flegrei caldera (Italy).

In particular, the SBAS – DInSAR analysis carried out on Long Valley caldera, has been performed by using 21 descending orbit SAR images, acquired by the ERS1/2 sensors during the June 1992 - August 2000 time interval. This analysis allowed us to retrieve the mean deformation velocity map and the corresponding displacement time series, for each coherent pixel of the investigated area. These information provide an effective picture of the geometry and evolution of the deformation phenomena of the caldera which is characterized by a succession of background deformation and unrest crises (1997-1998). In addition, we have performed a cross correlation analysis between the time series of the maximum deforming coherent pixel relevant to the Resurgent Dome and all remaining points of the zone. This allowed us to separate the regional and local component of the observed deformation field.

For what concerns the Tenerife Island case study, our analysis evolved 55 SAR images acquired by the ERS 1/2 sensors in the 1992-2005 time interval. The computed mean deformation velocity map shows a significant subsidence pattern localized on the Pico de Teide and in the surrounding caldera region. In this case the analysis also reveled a good spatial fit between the geometry of the retrieved deformation and the main volcano structures of the island (i.e. horseshoe shaped caldera).

The final result have been focused on the Campi Flegrei caldera a volcanic densely populated rea located to the west of city of Naples (Italy). In this case we used all the available ENVISAT ASAR data acquired on the swath I2 from ascending (track:129 – frame: 809) and descending (track: 36 – frame: 2781) orbits, in order to generate deformation time series extending from 2002 to date; moreover we combined ascending and descending data to separate the vertical and horizontal components of the deformation velocity.

The processed data have revealed the start of new uplift phase of Campi Flegrei caldera with the uplift trend becoming very clear starting from June 2005. The area of maximum deformation is localized in the centre of the town of Pozzuoli, with the renewed activity showing a maximum velocity of about 2.8 mm/year. We also show that with the respect the most recent unrest episode occurred in summer 2000, this phenomenon is lasting for a longer time, although with a significantly slower velocity.

References

[1] P. Berardino, G. Fornaro, R. Lanari and E. Sansosti, “A new Algorithm for Surface Deformation Monitoring based on Small Baseline Differential SAR Interferograms,” IEEE Trans. Geosci. Remote Sens , vol. 40, pp. 2375-2383, November 2002.