THE EXTENDED SBAS TECHNIQUE FOR GENERATING FULL RESOLUTION ERS/ENVISAT DEFORMATION TIME-SERIES

M. Bonano[1,2], M. Manunta[1], M. Marsella[2], R. Lanari[1]

[1] IREA-CNR, via Diocleziano 328, 80123, Napoli, Italy
[2]Università "La Sapienza", 00185, Roma, Italy

1. INTRODUCTION

We extend the Small BAseline Subset (SBAS) Differential SAR Interferometry (DInSAR) approach in order to generate deformation time-series at full spatial resolution scale from long sequences of ERS-1/2 and ENVISAT (IS2 swath) SAR data, acquired with the same illumination geometry. In particular, we avoid the generation of ERS/ENVISAT cross-interferograms, severely affected by noise phenomena, and we focus on single-platform interferograms only (i.e. ERS/ERS and ENVISAT/ENVISAT interferograms) that are properly combined by applying the SBAS approach. Moreover, we exploit the doppler centroid variations of the post-2000 ERS-2 acquisitions and the carrier frequency difference between the ERS-1/2 and the ENVISAT systems, thus maximizing the number of investigated SAR pixels and improving their geocoding.

The presented results, achieved by applying the proposed approach to two ERS/ENVISAT dataset relevant to the Napoli Bay area (southern Italy), demonstrate the effectiveness of the extended SBAS technique to detect and analyze the temporal evolution of deformation phenomena at the scale of single buildings and man-made structures and on a temporal interval of more than 15 years.

2. ERS/ENVISAT FULL RESOLUTION SBAS TECHNIQUE

In this work we focus on the technique referred to as Small BAseline Subset (SBAS) approach [1][2], that allows us to investigate ground deformation at two distinct spatial scales, referred hereafter to as regional and local scale, respectively. At the regional scale the technique exploits average (multi-look) interferograms and permits to generate mean deformation velocity maps and the corresponding time-series relevant to very large areas (typically of about 100 x 100 km), with a ground resolution that is typically of about 100 x 100 m. At the local scale, the technique exploits the single-look interferograms, generated at full spatial resolution, in order to detect and analyze local deformation that may affect single buildings and man-made structures.

The key point of the SBAS technique is the selection of the data pairs involved in the generation of the interferograms; in particular, only data pairs characterized by small spatial and temporal separation (baseline) between the acquisition orbits are selected in order to mitigate the noise (decorrelation phenomena) affecting the computed interferograms; on the other hand, this selection may lead to the distribution of the generated small baseline interferograms in subset separated by large baselines [1]. Accordingly, the deformation time-series are computed by considering the available interferograms and searching for a least squares solution with a minimum norm energy constraint; this result is achieved by applying the singular value decomposition (SVD) technique which allows us to easily merge the information retrieved from the different subset [1].

In this work we extend the SBAS approach in order to generate deformation time-series at full spatial resolution from long sequences of ERS and ENVISAT SAR data, the latter relevant to the IS2 swath. This result is achieved by adapting the two-scale SBAS approach [2] to account for the ERS/ENVISAT processing strategy proposed in [3]. This approach, originally developed for multi-look differential interferograms, considers the images acquired by the ERS and ENVISAT radar systems as belonging to independent subset; accordingly, no ERS/ENVISAT cross-interferograms, characterized by strong decorrelation effects due to the slightly different carrier frequencies of the two radar systems, are produced and the combination of the conventional ERS/ERS and ENVISAT/ENVISAT (IS2 swath) interferograms is easily carried out by applying the SBAS strategy without major changes. We remark that since we have to guarantee a temporal overlap between the data of the two sensors, we exploit also ERS-2 acquisitions carried out after 2000, i.e., following the ERS-2 system gyroscope failure events [4]; this leads to analyze ERS-1/2 images that, in some cases, are characterized by large doppler centroid values. These doppler centroid variations are profitably exploited in order to retrieve information about the sub-pixel azimuth location of the coherent SAR pixels. Moreover, we properly exploit also the carrier frequency difference of the ERS-1/2 and ENVISAT systems in order to maximize the number of investigated SAR pixels, also identifying those exhibiting a response significantly deviating from a single scatterer backscattering response.

3. RESULTS

In order to demonstrate the effectiveness of the proposed full resolution ERS/ENVISAT DInSAR approach, we have applied the extended SBAS technique to a SAR dataset relevant to the Napoli Bay area (southern Italy) composed by 71 ERS-1/2 and 39 ENVISAT acquisitions (swath IS2) acquired on ascending orbits (frame 809, track 129) and spanning the time period from 1993 to 2007. For the DInSAR interferogram generation we have imposed, for both the ERS and ENVISAT data pairs, a perpendicular baseline constraint of 400 m and a maximum temporal separation (temporal baseline) of 1500 days, while we have assumed a doppler centroid variation not larger than 1000 Hz. Moreover, precise satellite orbital information and the Shuttle Radar Topography Mission (SRTM) DEM of the study area have been used for removing the topographic phase contribution.

To provide an overall picture of the detected deformation, we present in Figure 1 the full resolution deformation velocity map, relevant to the coherent pixels and superimposed on an orthophoto of the investigated area. Note that this representation is visually effective and allows us to provide an average information (with respect to time) of the detected deformation.

Figure 1 clearly shows that significant deformation patterns are present in several areas which can be easily identified: on the left hand side, it is evident the deformation phenomenon affecting the Campi Flegrei caldera; almost in the center of the image, we reveal the subsidence effects located within the highly urbanized Vomero quarter in the city of Napoli; concerning the Mt.Vesuvio area, on the right hand side of the picture, displacements are present on its summit as well as around its base. The SBAS-DInSAR results have been validated by exploiting independent geodetic measurements (GPS and leveling), that were made available to us by the INGV.

4. 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, No 11, pp. 2375-2383, 2002.

[2] Lanari, R., Mora, O., Manunta, M., Mallorqui´, J.J., Berardino, P. and Sansosti, E., “A small baseline approach for investigating deformations on full resolution differential SAR interferograms”, *IEEE Transactions on Geoscience and Remote Sensing*, Vol. 42, pp. 1377-1386, 2004.

[3] A. Pepe, E. Sansosti, P. Berardino, and R. Lanari, “On the Generation of ERS/ENVISAT DInSAR Time-Series Via the SBAS Technique”, *IEEE Geoscience and Remote Sensing Letters*, Vol. 2, No 3, pp. 265-269, 2005.

[4] Miranda, N., Rosich, B., Santella, C. and Grion, M., “Review of the impact of ERS-2 piloting modes on the SAR Doppler stability”, in *Proc. Fringe 2003*, Frascati, Italy, December 2003.

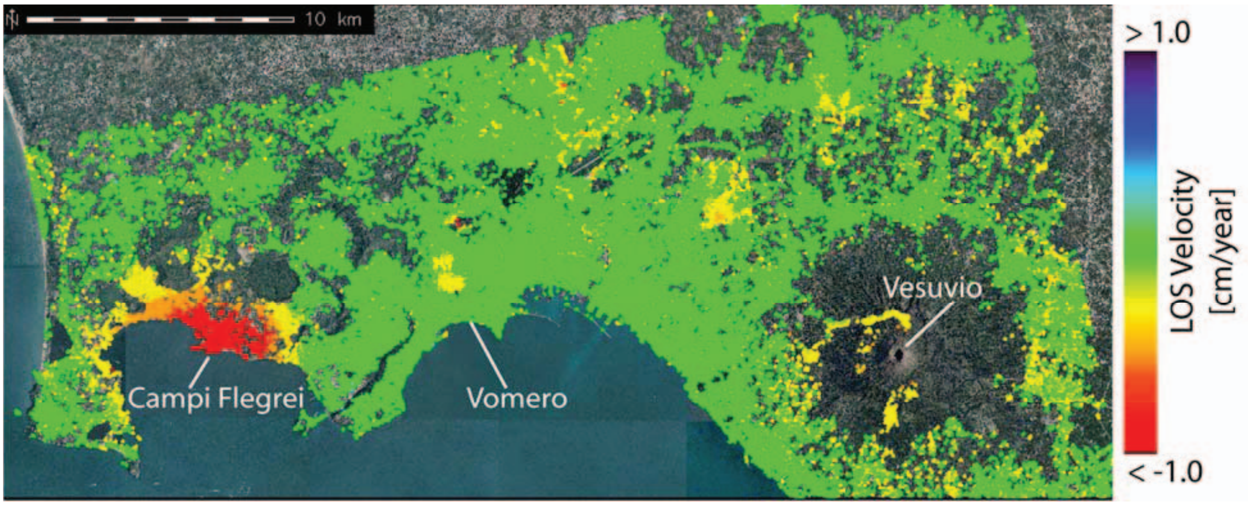

Figure 1 - Full resolution mean deformation velocity map relevant to the Napoli Bay area (southern Italy) superimposed on an optical image of the investigated zone. The Campi Flegrei caldera, the Vesuvius volcano and the Vomero quarter, within the city of Napoli, have been highlighted.