Geophysical Research Abstracts
Vol. 12, EGU2010-12995, 2010
EGU General Assembly 2010

Non-invasive deformation analysis of historical buildings through the advanced SBAS-DInSAR technique: the case of the city of Roma (Italy)

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The monitoring of urban areas and man-made structures is of key importance for the preservation of artistic, archaeological and architectural heritage. In this context, the remote sensing techniques may allow non-invasive analysis of large areas by exploiting long time series of satellite data. Among these techniques, the Synthetic Aperture Radar (SAR) Interferometry (InSAR) has already demonstrated to be an effective tool for monitoring the displacements occurring in the historical and artistic heritage located in the historical city centers. As a matter of fact, the InSAR technique allows producing spatially dense deformation maps with centimeter to millimeter accuracy, by exploiting the phase difference (interferogram) of temporally separated SAR images relevant to the same analyzed area.
In order to guarantee the monitoring of urban area displacements, it is strategic to provide very long term deformation time series by also exploiting SAR data acquired by different sensors. Accordingly, ERS/ENVISAT data archive, providing acquisitions spanning the 1992-2010 time period, might allow us generating very long term deformation time-series. However, an ERS/ENVISAT data combination is limited by the two sensors slightly different carrier frequencies: 5.331 GHz for the ENVISAT sensor and 5.3 GHz for the ERS one. Therefore, because the interferometric phase is dependent on the radiation wavelength, the generation of conventional ERS/ENVISAT cross-interferograms is strongly affected by the induced decorrelation effects.
In this work we show the effectiveness of the Small BAseline Subset (SBAS) (Berardino et al., 2002; Lanari et al., 2004) approach for the conservation, monitoring and risk prevention of cultural heritage. Indeed, the SBAS technique allows us to produce deformation time series at the scale of the single building by processing very long sequences of ERS-1/2 and ENVISAT (IS2 swath) SAR data, acquired with the same illumination geometry. In particular, the SBAS approach exploits only conventional ERS/ERS and ENVISAT/ENVISAT differential interferograms, in order to limit the decorrelation effects and improve the number of the detected coherent points. Accordingly, this method may play a key role for supporting the study and conservation strategies of the historical built heritage, monuments and artistic artifacts, due to its capability of generating deformation time series spanning time interval of more than 15 years.
The presented results, achieved by applying the full resolution SBAS approach to an ERS/ENVISAT dataset relevant to the city of Rome, demonstrate the effectiveness of this technique to detect and analyze the temporal evolution of possible deformation phenomena affecting historical buildings within the investigated 1992-2009 time period.

[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.