Geophysical Research Abstracts, Vol. 8, 07930, 2006
SRef-ID: 1607-7962/gra/EGU06-A-07930

Survey and geological characterisation of land subsidence phenomena in the Lucca plain (Italy) using PSInSAR

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Spaceborne SAR interferometry (InSAR) was employed to measure ground settlements induced by groundwater extraction over the south part of the Lucca plain (Tuscany, Italy). This technique enables spatially detailed mapping of ground displacements, thanks to its extensive spatial coverage, good spatial resolution and high precision in the deformation measurement. The Permanent Scatterers (PSInSAR) configuration of radar interferometry was exploited. The area was monitored through the processing of two different data set of satellite images. For the time interval 1992-2002 ERS-1 and ERS-2 radar images were used while for the time period 2003-2005 data from Radarsat were exploited. The PS analysis allowed the identification of the land subsidence phenomena by mapping the spatial distribution of ground displacements. The resulting density of Permanent Scatterers, even if the look angles and signal polarisation are different, remained similar for both ERS and Radarsat data.

The PS measurements were validated using conventional levelling data available over the area of interest spanning the time period 1995-1996. The comparison showed a high agreement between the two data set, with residuals lower than one millimetre, confirming the reliability of the InSAR derived measurements. To obtain a better understanding of spatial distribution of ground settlements, as inferred from InSAR, maps of the piezometric levels of the main aquifer, spanning the same time interval as the SAR data, were collected. To check the existence of spatial correlation between highest values of water withdrawal and superficial deformation rates we overlaid the

map of changes in water table levels between 1992 and 2002 to the subsidence map from the same period. Moreover, a stratigraphic reconstruction of the underground materials, obtained from the available boreholes was carried out aimed at mapping the thickness of compressible terrains. Such an analysis highlighted the correspondence between areas characterised by high deformation rates and high values of groundwater fluctuations and thickness of clays and silts helping us to explain the origin of the displacement's spatial distribution. This was fundamental for the definition of mitigation strategies. Moreover, the displacement time series obtained from the PS analysis were compared with piezometric groundwater measurements acquired on several wells since the Seventies. The comparison, showing a strict correlation between water table changes and land subsidence, helped us to evaluate the cause-effect relations between the two phenomena.