

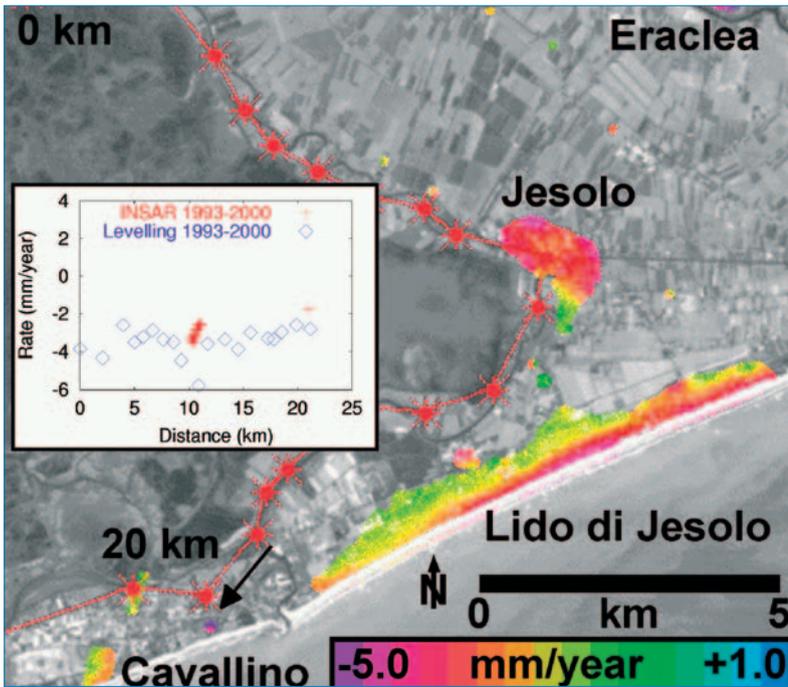
Land Subsidence Monitoring Service *in the Lagoon of Venice*



Land subsidence due to natural and anthropogenic causes has represented one of the most serious environmental problems for the Lagoon of Venice. Land subsidence has increased the vulnerability and the geological hazard (i.e. river flooding, riverbank stability, intrusion of seawater in the aquifer system, deteriorating of the littoral sectors with a general coastline regression and an increment of the sea bottom slope close to the shoreline) of these areas, a large portion of which lies below the mean sea level. After the regulation of groundwater exploitation from the Venetian aquifer-aquitard system, a remarkable slowing down of the induced subsidence in Marghera (industrial zone), in the historical center of Venice and along the littorals was ascertained in the 1970's. Recent studies have shown that land subsidence is still in progress in the southern and northern coastal areas and in the nearby mainland. In these areas groundwater is extracted from artesian wells, thicker and more

compressible Holocene sediments are present, and organic soil oxidation takes place in reclaimed zones.

Until 1999, levelling of the Venice region was carried out only along the coast and the lagoon edges and the monitoring network was composed by benchmarks along single levelling lines; a fine grid network was established only in the city of Venice. In recent years, the levelling network has been updated to cover with a grid of about 1000 benchmarks all the southern part of the Lagoon, and plans exist to cover also the northern sector. The same network used for the levelling surveys is also considered for differential GPS measurements. In addition to these ground-based methods, differential SAR interferometry using long series of SAR data and the interferometric point target analysis have emerged as very promising tools for the monitoring of land subsidence at high spatial resolution and with a more complete spatial coverage.



The objective of the Data User Programme (DUP) Small Services Project VENEZIA - started in November 2001 and to be completed in November 2003 - is to implement a land subsidence monitoring service in the Lagoon of Venice for regional administrative and water authorities. An important element of the project is the integration of SAR-based monitoring techniques (conventional differential SAR interferometry and the interferometric point target analysis) with levelling and GPS surveys into an overall database and information system capable to provide the best knowledge of the subsidence process to the regional, administrative and water authorities that manage the Po Plain area around the Lagoon of Venice. Results of the project prove that this integration in the knowledge of the subsidence process can be efficiently obtained for both a back-analysis during the last decade and future monitoring of evolutionary trends. The acquisition of these physical-environmental characteristics is at present necessary for urgent restoring works and conserving plans of the lagoon's ecosystem. In future, knowledge of land subsidence may assist potential exploitations of the underground resources, i.e. water in coastal and catchment areas and gas off the littoral.

As it can be observed in the figures for two specific areas around the Lagoon of Venice, SAR interferometry exhibits complementary characteristics to the levelling surveys, because it has the capability to map urban areas at high

spatial resolution. In particular, SAR interferometry is very useful to perform detailed investigations in coastal areas: in Chioggia and Jesolo a significant seaward gradient in land subsidence, practically impossible to be detected by other traditional monitoring techniques like geometric leveling and differential GPS, is visible. A critical situation is also observed in Eraclea, where the sinking velocity reaches 4 mm/year. The high precision levelling surveys, on the other hand, are used outside of the cities, as to the east of Chioggia, and to set up a reference point for the SAR subsidence values. The high accuracy of the two surveying techniques is confirmed by their cross-validation along the levelling lines.

