Ground Deformation Signals of Thessaly Plain (Greece) from SAR Interferometry

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Abstract

Persistent Scatterers Interferometric (PSI) techniques are routinely applied for ground deformation measurement, providing continuous spatial coverage, that is missing in other space-borne geodetic techniques, such as GNSS and optical levelling. During the course of their development, automated processing schemes, as well as wide area coverage products were presented paving the way for an operational exploitation of the technique for geohazards monitoring. Nonetheless, there are still few cases where selection of the proper processing scheme and definition of processing parameters is required, not only to optimise performance but to allow extraction of robust results. However, due to the complexity of these application sites both in terms of environmental conditions and complexity of the deformation signal the implementation of PSI techniques is not favoured.

Thessaly plain, located at the central part of Greece mainland, could comprise such a case. The over-exploitation of the underground aquifer systems resulted in severe settlement phenomena causing on an annual basis significant damages at national infrastructures (e.g. roads and railways) and private properties as well. Although the cause to the problem is already identified, due to the severity of the consequences, the lack in understanding in depth the phenomena, in terms of magnitude, spatial extend and evolution, underlines the requirement of accurate measurements in support of decision taking and prevention actions by the local authorities.

The European Space Agency’s long SAR archive is currently the only source of available data most suitable for the extraction of the historical information of the settlement evolution in the region and the estimation of the general trends required for management planning. However, even though numerous SAR acquisitions are available covering, the random distribution of the acquisitions in time together with the non-linearity of the deformation signal places constraints during the interferometric processing. As such, in our case the problem is mainly related to the absence of sufficient temporal sampling over the periods of severe settlement due to groundwater over-pumping which appears as an abrupt shift in the SAR deformation histories, introducing in this way issues that have to be carefully addressed within the selected processing scheme.

Interferometric time series analysis presented herein involves the entire archive of ENVISAT for both ascending and descending orbits covering a period of almost 10 years. Processing was performed using the GAMMA software package for co-registration and geocoding purposes, as well as, for the generation of the initial differential interferograms, and StaMPS software for combined PS and SBAS-like analysis. Although the area is consisted mostly of agricultural land, sufficient number of point targets well-distributed over the entire plain was obtained, permitting the recognition of spatial variations apart from temporal changes.

Our findings outline the south part of the Eastern Thessaly plain as the mostly affected area, whereas local subsidence patterns were recognized elsewhere. Estimated mean deformation rates over the area were at the order of a few millimetres per year, though displacements up to a couple of centimetres within short time intervals of several months, in specific during summer and autumn periods, were recognized. The results were confirmed by processing independent data stacks from different tracks, highlighting the unique behaviour of the area due to intense water pumping. In addition, it is shown that displacement rate maps presenting average values over specific time spans are sometimes not sufficient and that full exploitation of the capacity of the PSI techniques by detailed examination of the displacement time series could reveal valuable information to geotechnical engineers and planners.

Finally, the vertical displacement component was calculated combining ascending and descending PSI results and the final outputs were integrated into a GIS environment for hazard susceptibility analysis following a commonly applied zoning procedure.