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Automated classification of Permanent Scatterers time-series based on statistical characterization tests

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The application of space borne synthetic aperture radar interferometry has progressed, over the last two decades, from the pioneer use of single interferograms for analyzing changes on the earth's surface to the development of advanced multi-interferogram techniques to analyze any sort of natural phenomena which involves movements of the ground. The success of multi-interferograms techniques in the analysis of natural hazards such as landslides and subsidence is widely documented in the scientific literature and demonstrated by the consensus among the end-users. Despite the great potential of this technique, radar interpretation of slope movements is generally based on the sole analysis of average displacement velocities, while the information embraced in multi interferogram time series is often overlooked if not completely neglected. The underuse of PS time series is probably due to the detrimental effect of residual atmospheric errors, which make the PS time series characterized by erratic, irregular fluctuations often difficult to interpret, and also to the difficulty of performing a visual, supervised analysis of the time series for a large dataset.

In this work is we present a procedure for automatic classification of PS time series based on a series of statistical characterization tests. The procedure allows to classify the time series into six distinctive target trends (0=uncorrelated; 1=linear; 2=quadratic; 3=bilinear; 4=discontinuous without constant velocity; 5=discontinuous with change in velocity) and retrieve for each trend a series of descriptive parameters which can be efficiently used to characterize the temporal changes of ground motion. The classification algorithms were developed and tested using an ENVISAT datasets available in the frame of EPRS-E project (Extraordinary Plan of Environmental Remote Sensing) of the Italian Ministry of Environment (track "Modena", Northern Apennines). This dataset was generated using standard processing, then the time series are typically affected by a significant noise to signal ratio.

The results of the analysis show that even with such a rough-quality dataset, our automated classification procedure can greatly improve radar interpretation of mass movements. In general, uncorrelated PS (type 0) are concentrated in flat areas such as fluvial terraces and valley bottoms, and along stable watershed divides; linear PS (type 1) are mainly located on slopes (both inside or outside mapped landslides) or near the edge of scarps or steep slopes; non-linear PS (types 2 to 5) typically fall inside landslide deposits or in the surrounding areas. The spatial distribution of classified PS allows to detect deformation phenomena not visible by considering the average velocity alone, and provide important information on the temporal evolution of the phenomena such as acceleration, deceleration, seasonal fluctuations, abrupt or continuous changes of the displacement rate. Based on these encouraging results we integrated all the classification algorithms into a Graphical User Interface (called PSTime) which is freely available as a standalone application.