Geophysical Research Abstracts
Vol. 17, EGU2015-15182, 2015
EGU General Assembly 2015

Landslide monitoring by Terrestrial SAR Interferometry: critical analysis of different data processing approaches

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In last years, Terrestrial Synthetic Aperture Radar Interferometry (TInSAR) became a key technology in the field of landslide and structures/infrastructures displacement monitoring. Thanks to undoubted advantages such as i) widespread information, ii) fully remote applicability over long ranges and iii) high accuracy, this technique promises to be a very effective solution for a lot of geological and engineering issues. Even if this technique was born for interferometric analyses (basing on the phase differences between SAR images collected at different time intervals), recent studies demonstrated its reliability also with non-interferometric processing approaches, based on the amplitude tracking of high-reflectivity objects (i.e. corner reflectors). Furthermore, both approaches can be used for both continuous and discontinuous monitoring, thus opening to a wide spectrum of applications for different purposes. The aim of this work is to provide information about the reliability and the accuracy of TInSAR technique in its different kind of applications. In the frame of this work, two case studies of landslides monitored with a continuous acquisition mode (about 5 minutes sampling rate) have been investigated. The first case study consists of superficial instability problems mainly related to huge rainfalls and works, leading to non-linear displacements up to 10 mm/day. In order to assess the impact of discontinuous acquisition mode, data subsampling of one data/day for an overall monitoring period of about 3 months has been performed. The comparison between discontinuous and continuous interferometric processing approach allowed the identification of some aliasing and ambiguity problems in the discontinuous approach, especially in periods when high displacement rates were affecting the slope. Nevertheless, in most of such cases, it was still possible to provide qualitative information about criticalities, even if a precise estimation of displacement entities was precluded.

The second case study is a road embankment affected by an instability problem leading to continuous and almost linear displacement rates up to 3-4 mm/day. Also in this case, TInSAR collected dataset were subsampled in order to simulate a discontinuous monitoring with 1 image/day sampling rate for an overall period of about 1 month. The displacements of 7 corner reflectors (characterized by a very high peak-to-background amplitude) were investigated by a non-interferometric approach based on the amplitude variation tracking at a sub-pixel scale. Amplitude-based results were compared with those from the interferometric approach, based on the analysis of the same subsampled data. Although the accuracy of the amplitude-based method depends on the dimensions of SAR pixel (which in turn depends on the sensor-target distance) and is much lower than the phase-based method, an overall good agreement between the two approaches has been achieved. Specifically, the errors for 6 of 7 monitoring points were within the expected site-specific accuracy of the amplitude-based method (about 1,5 cm).

The experience gained by the critical analysis of different TInSAR data processing allows a quantitative estimation about the expected accuracy and reliability of the technique in the design of future monitoring projects, representing a useful tool for the optimization of funds and the identification of the best monitoring solution.