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Spatio-temporal analysis of SAR based time series for slope instability characterization: the Corvara in Badia landslide (Dolomites, Italy)

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The aim of this study is to estimate the influence of different forcing factors acting on instability phases of a slow alpine earthslide-earthflow, by means of the characteristics of decomposed deformations signals derived by displacement rates measured in its different sectors.
In this work we analyze a slow landslide located ESE from Corvara in Badia, a famous tourist area in the Dolomites (NE Italy). Road, infrastructure, ski and other recreational facilities, isolated buildings close to the town of Corvara and finally an artificial reservoir for snow production are threatened and occasionally damaged by this mass movement. It flows from 2000m s.l. to 1500m s.l. where a paleo-landslide deposit is partially covered and re-activated.
In the last 10 years the Province of Bolzano carried out discontinuous GPS surveys between 5 and 1 times per year to define the landslide's level of hazard. The landslide volume is resulted to be 30Mm3, extending downslope for approx. 3km, with displacement rates between few centimeters and slightly less than 10m per year. To analyze this area we used data from active radar sensors (SAR – Synthetic Aperture Radar). The SAR-based dataset consists in high resolution X-band SAR data from the Cosmo SkyMed (CSK) mission acquired every 8 days from August 2010 to September 2011. Part of the 38 CSK scenes contain the back-scattering signal from 17 artificial reflectors (AR) installed along the AOI and partially on existing GPS benchmarks for data validation and integration. The ARs back scattering signal has been elaborated in order to track their displacement from August 2010 to September 2011, in the lower zone of the landslide, as well as from March 2011 to September 2011 in the higher part, excluding the period when the snow was covering the surface.

The signals have been analyzed with Fourier and wavelet methods to identify the different frequencies and nature of the components. T and Mann-Kendall tests have been used to assess the presence of trends. Fits with exponential functions of the de-trended and de-seasonalized signal have been performed to identify the presence of dissipating deformations.
We observed that the signal of velocity and acceleration is characterized by the coexistence of different factors: first, periodic signals associated to seasonal and gravitational kinematic behavior; second, decay effects due to instability events.
Moreover, using different points is possible to observe the signal propagation both in time and space. This analysis allow us to determine the spatio-temporal scale of different forcing events and their effect on the total landslide area.
Finally, this study represent a new approach for identify the spatio-temporal nature of different factors in the evolution of the landslide for setting-up a system of conscious prediction of maintenance tasks of the exposed structures. The use of the SAR data demonstrated to be an innovative tool for high temporal resolution surveys with a big amount of points that in comparison with GPS surveys results to be economically convenient in wide AOI.