Geophysical Research Abstracts
Vol. 20, EGU2018-5275, 2018
EGU General Assembly 2018

Integrating back analysis and forward modelling of a debris flow with GB-InSAR data to assess the risk in a mountainous valley floor

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Debris flows are water-laden collapsing masses of soil and fragmented rocks. Those related to slope failures rush down mountainsides, funnel into stream channels and form thick deposits on valley floors. Usually, they are also associated with intense erosion along their path, that leads to a substantial increase in volume, runout distance, and disruptive energy. The prediction of landslide runout and its effect is essential in landslide risk assessment, especially in populated mountainous areas. In these areas, in fact, most human activities are concentrated in valley floors, that correspond to the areas most impacted by the flow. Both analytical and empirical methods can be employed to evaluate the runout extension.
The 4th November 2010 debris flow event, detached from the Rotolon DSGSD detrital cover (Vicentine Pre-Alps, NE Italy) and channelized into the Rotolon creek riverbed, was modelled by means of DAN-3D numerical code. The debris flow travel distance was roughly 4 km, and many damages to hydraulic works and to four villages situated along the creek banks were reported. The back analysis of the 2010 runout showed that amongst all the available rheological kernels, the best one is the Voellmy-type. Varying the rheological reference parameters, in fact, the model could reproduce with high accuracy: i) debris flow impact area; ii) deposit thickness; iii) velocity; iv) final flow erosion volume.
Based on the back analysis results, a forecasting analysis to assess the Rotolon valley exposure to possible future debris flow events was performed. Also this analysis was carried out by means of DAN-3D. i) The same input data of the back analysis; ii) a new possible source area (detected by means of GB-InSAR displacement data analysis); and iii) different thicknesses (hypothesized on the basis of the statistical analysis of the differences between the pre- and post-2010 event DTMs), were taken into account. These simulations produced impact area maps useful to evaluate the different future debris flow scenarios. The results showed that the integration of the modelling technique with ancillary data (such as detailed geomorphological and topographic maps, location and characteristics of the hydraulic works along the creek bed), together with the GB-InSAR-derived displacement maps, can be a very useful tool for the scientific community and local administrations to manage the problem related to debris flow events. This working method could also represent a standard procedure in cases of areas prone to different types of debris flow where also are available the GB-InSAR displacement monitoring system data. Nevertheless, the final reliability of the proposed method lies in the skill of expert operators regarding the choice of plausible volumes of possible future debris flow events.