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## Definition of a new multi-level early warning procedure for landslide risk management

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The identification of potentially critical events involving unstable slopes is a major aspect in the field of natural hazards risk mitigation and management. In this framework, Early Warning Systems (EWS) exploiting advanced technologies represent an efficient approach to decrease the risk generated by landslide phenomena, allowing to reduce the possibility of damages and losses of human lives. EWS effectiveness has increased significantly in recent years, thanks to relevant advances in sensing technologies and data processing. In particular, the introduction of innovative monitoring instrumentation featuring automatic procedures and increased performances in terms of sampling rate and accuracy has permitted to develop EWS characterised by a near-real time approach. Among the several aspects involved in the development of a reliable Early Warning System, one of the most important is the ability to minimize the dissemination of false alarms, which should be avoided or identified in advance. The approach proposed in this study represents a new procedure aimed to assess the hazard level posed by a potentially critical event, previously identified by analysing displacement monitoring data. The process is implemented in a near-real time EWS and defines a total of five different hazard levels, on the basis of the results provided by two different models, namely an accelerating trend identification criterion and a failure forecasting model based on the Inverse Velocity Method (IVM). In particular, the forecasting analysis is performed only if the dataset elaborated by the onset-of-acceleration model highlights a potentially critical behaviour, which represents a first alert level. Following levels are determined by different conditions imposed on three parameters featured by the failure forecasting model, i.e. dataset dimension, coefficient of determination R-squared, and number of sensors displaying an accelerating trend. As these criteria get fulfilled, it is assumed that the monitored phenomenon is gradually evolving towards a more critical condition, thus reaching an increasing alert level depending on the analysis results. According to this classification, it is possible to set up for each single threshold a dedicated warning message, which could be automatically issued to authorities responsible of monitoring activities, in order to provide an adequate dissemination of information concerning the ongoing event. Moreover, the proposed procedure allows to customize the alert approach, giving the possibility to issue warning messages only if a certain Level is reached during the analysis.