



Reliability of landslide early warning systems operational worldwide

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A Landslide Early Warning System (LEWS) is a non-structural mitigation measure aiming at reducing the level of risk through the reduction of the elements threatened by a slope movement. It certainly constitutes a significant option, available to the authorities in charge of risk management and governance, among the many mitigation measures. The LEWSs can be employed at two different scales of analysis. Systems addressing single landslides at slope scale can be named local LEWSs, and systems operating over wide areas at regional scale can be referred to as territorial systems.

A review carried out by the author on the LEWSs operational worldwide, highlighted 52 systems, in particular, 28 at slope scale and 24 at a regional one. Before 2000 only few experiences of LEWSs were carried out worldwide. Since the beginning of the 21st century, increased knowledge on thresholds and upgraded technologies in weather forecast and monitoring have promoted the development and improvement of LEWSs around the world as risk mitigation option, both at slope and regional scales. The review highlighted that the scale of analysis influences several aspects connected to the design and employment of LEWSs, such as: actors involved, types of landslide addressed, monitoring methods and variables, number of warning levels.

As general remark, to design and operate these systems it is important to clearly have in mind a conceptual model of all the fundamental components of a LEWS. An omission or an underestimation of any component may indeed reduce the reliability of the system, eventually leading to its failure or termination. The reliability of a LEWS can be assessed as a function of the correctness (i.e. warning model efficiency) and effectiveness of the warnings issued. In particular, false alerts lead to economic losses, i.e. low efficiency of the system, and/or inconveniences for the public, for instance: a road closure or the worthless deployment of civil protection agents and rescue teams. On the other hand, missed alerts can generate a higher number of victims and can evolve in unexpected damage to infrastructures, i.e. low effectiveness of the system.

In conclusion different aspects can be considered to evaluate the reliability of local and territorial systems, differentiating among issues related to the efficiency and the effectiveness of the system. Among them, for both scales of analysis the continuous performance evaluation of the warnings issued contributes to increase the efficiency of the system. On the other hand the evaluation of the public behaviour during emergency phases, i.e. when high warning levels are issued, is paramount for assessing the system effectiveness. While the evaluation of the performance of a warning model is addressed by a number of recent studies and applications from several authors, there is still a lack of literature contributions dealing with education and people response to warnings and, thus, with how to quantify the overall effectiveness of a LEWS.