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Instrumental monitoring of lahars for warning purposes: new developments along the Colima Volcano, Mexico

Velio Coviello (1), Lucia Capra (1), Rosario Vázquez (1), Víctor H. Márquez (2), and Sergio Cruz (3)

(1) UNAM, Centro de Geociencias, Querétaro, Mexico (vcoviello@geociencias.unam.mx), (2) Conacyt-SisVoc-UdG, Mexico, (3) PCIC-UNAM, Mexico

Early Warning Systems (EWSs) for rapid flow-like landslides can be classified into two main types: advance- and event-systems. Advance EWSs predict the flow occurrence by monitoring the parameters that may lead to initiation conditions, typically rainfall. This kind of EWSs are prone to a high number of false alarms because they are strongly affected by uncertainties in both precipitation measurements and in the estimate of rainfall thresholds. Event EWSs are based on the instrumental detection of the flow when it is already in progress. Those systems can be particularly effective to protect vulnerable infrastructures such as communication routes that do not require an excessively long alert time. However, having a much smaller lead time than advance-systems, their effectiveness strictly depends on the possibility to perform accurate and rapid measurements and to automatically process, store and validate monitoring data, that is to integrate an effective warning algorithm.

In mountainous regions, several instrumented catchments exist where debris flow monitoring is performed using stage sensors, video cameras, and ground vibration detectors (GVDs). For early warning purpose, the possibility to detect debris flows from a distance is an important advantage of GVDs. In addition, most monitoring devices need to be installed in the channel bed or very close to it, with consequent great danger to be destructed. Consequently, a growing number of monitoring systems of active basins integrate a linear array of GVDs distributed along the channel, in safe locations. A debris flow warning algorithm based on geophone data was recently developed and implemented in the Gadria testing field for EWSs, Northeastern Italian Alps. This algorithm uses the Signal-to-Noise Ratio (SNR) as warning parameter instead of a classical intensity/duration threshold. The event detection algorithm adopts a non-simultaneous triggering condition requiring that at least two geophones trigger in order, upstream to downstream. Here we propose a new application and development of this method to early detect and characterize rain-triggered lahars occurring along the Colima Volcano, one of the most active volcanoes in Mexico. Two monitoring stations are installed along the Southwestern flank of the volcano, in the Montegrande and the Lumbre basins. Both sites are equipped with a GVD array and a videocamera. Along the Montegrande ravine is also installed an infrasound sensor while the Lumbre monitoring station integrates a flow stage sensor. The new detection algorithm, currently under testing, is still based on the SNR but detected by two different sensors installed at the same cross-section: a geophone paired with a stage sensor or an infrasound device. Preliminary results show how this can be an effective solution to adopt along channels where is possible to monitor only one cross-section with a heavily instrumented station.