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A general and simple methodology to calibrate seismic instruments for lahar flow quantification: preliminary results from Tungurahua and Cotopaxi volcanoes, Ecuador.

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Lahar quantification, seismic signals, calibration, Buckingham Pi-Theorem

Lahars are volcanic phenomena that occur whether volcanoes are active or not. Due to their physical characteristics and behavior, lahars represent significant hazards for life and property placed even far from their source volcanoes. Thus, it is common that instrumental networks are displayed to provide early warnings for lahar events. One typical approach is to install seismic instruments that detect the noise produced by lahars. Such noise can be characterized, and then used to identify the occurrence of lahars and finally to trigger alerts. Seismic signals may also be used in order to quantify lahar flows, by providing estimations of parameters like instant discharge and cumulated/total lahar volume in near real-time. Such information may be much more useful when early warnings are required. However, individual seismic instruments need to be previously calibrated in order to deliver such information, which implies the field observation and measurement of lahar parameters at every instrument prior to an emergency event. This can be difficult to achieve. Here we present a general methodology to calibrate seismic instruments in order to obtain quantitative information of flowing lahars. The methodology is based on the theory of physically similar systems (Buckingham Pi-Theorem), which provides a simplified framework to correlate the main variables of the studied system: S (seismic signal), x (distance between lahar and seismic detector), Q (lahar discharge rate) and d (lahar density). Equations correlating Q and S are obtained from this analysis, where Pi-numbers are constants directly related to the type of sensor used for detection. Thus, one specific type of instrument may be calibrated with a few events, and may lately be installed anywhere the substratum characteristics remain similar. This approach has been used to calibrate seismic instruments installed at Tungurahua and Cotopaxi volcanoes in order to provide early warnings for lahars.